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(71) Applicant and
(72) Inventor: KASSIS, Fahim [AU/KW]; Al-Ahmadiah Contracting & Trading, P.O. Box 446 Safat, 13005 Kuwait (KW).

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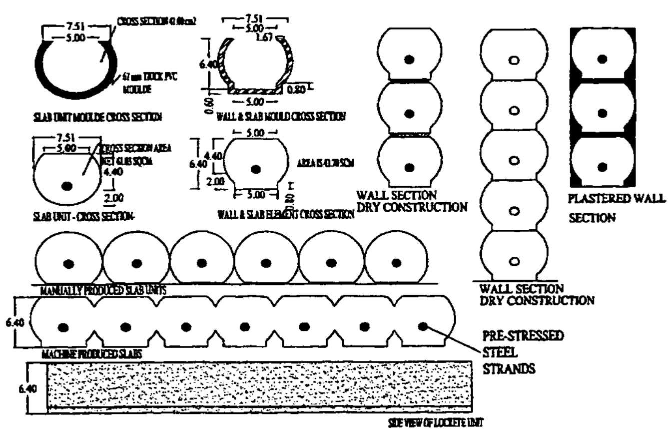
(54) Title: REINFORCED CONCRETE ELEMENT



(57) **Abstract:** A system for walls and structural slabs is disclosed. It consists of units of a pre-cast reinforced concrete element that has a special form design, fabrication methods and utilisation. The element has a circular section, variable lengths and flat surface on the top and bottom sides (2). It has a sectional area of 4170 sq mm. The optimum preferred dimensions of the cross section are 64 mm high and 75 mm wide (1). The element has an optimum shape that reduces the materials used yet provides the structural performance required. When stacked vertically between two structural framing columns, the elements form non-load-bearing walls system (3). The elements form structural diaphragm when horizontally laid side by side in a butt-jointed manner, supported on both ends by means of structural framing beams. Plain concrete topping to the necessary thickness is cast over the diaphragm/elements, forming an integral reinforced concrete structural slab system (4). The elements are fabricated mechanically or manually. Manual fabrication using PVC moulds produces individual elements of various lengths. Machine fabrication allows production of jointed elements forming slabs of various widths and lengths.

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Reinforced Concrete Element

1. BACKGROUND

The following document describes an innovative technology in the design, fabrication and construction of a reinforced concrete element, referred to herein as ***Locrete***. ***Locrete*** is used as a building construction material for walls and slabs in addition to few other functions. It presents an effective solution for the efficient use of reinforced concrete material and offers a substantial cutback in cost, time, equipment, formwork, labour and the need of extensive technical know-how.

Generally, the main contributors to the cost of reinforced concrete include areas such as:

- Technical expertise, cost of design, supervision and skilled labor
- Cost of materials and material handling
- Equipment and labor
- Formwork and related labor
- Construction time

The predominant techniques used in reinforced concrete construction are mostly based on previously set models. The technical research on reinforced concrete as a building construction material is extensive with particular emphasis placed on its physical performance. Most of the applications in the field utilise heavy equipment, extensive amounts of formwork or a combination of both. Advanced technical know how is required but may not be readily available. All of these factors result in prohibitive or redundant costs.

Locrete addresses some of the identified issues of the existing systems by maximising the benefits of the material and concurrently reducing its cost. The innovative design of *Locrete* and its mode of production and easy construction lead to a substantial elimination of some of the redundant cost factors that are deep-seated in the standard *modus operandi*.

Locrete, as a building construction system, offers the following :

- The elimination of formwork for reinforced concrete slabs, resulting in direct cost saving and a positive environmental impact.
- The elimination of mandatory use of heavy equipment, intensive labor and advanced technical expertise.

- The substantial reduction in capital investment as a result of major savings achieved through the use of *Locrete* as an alternative building system.
- Substantial reduction in the time required for fabrication and construction of walls and slabs.

2. DISCLOSURE OF INVENTION

The proposed invention is a pre-designed, pre-cast reinforced concrete element that is characterised by its cross sectional form, variable lengths, mode of reinforcement and mode of production. The *Locrete* elements once combined, form a system. The system is used for construction of flat reinforced concrete slabs. In its individual form, the element can be utilised for other purposes such as walls of a building structure, partition walls, fencing, planters, tree support posts, pavements, retaining walls , etc.

Locrete is easily produced, in fact, it does not require a major technical know how to either produce or construct. It is easy to transport and handle without the use of heavy equipment.

Locrete is economical to fabricate and build and it is maintenance free.

2.1 Brief Description of Drawings

Figures 1- 4 include model drawings illustrating the ***Locrete*** element designs, dimension and areas of utilisation .

Figure 1 shows the sectional details of the *Locrete* element. The mould details, slab alternatives and wall sections. The gross sectional dimensions are 64 mm high and 75 mm wide. The cross section area of the element is 4170 square millimetres. The length of the element varies anywhere between 100 mm to 5000 mm. The gross width and height of the cross section can be varied to suit the required increase in the bearing capacity of the elements. The system allows optimal combination between the element cross sectional dimension and its bearing capacity.

Generally the only constant in the cross section is its design form.

The element dimensions are the inventor's choice. They are the dimensions used in the structural analysis enclosed in Appendix ii). The linear metre weight of a single element,

the load bearing capacity, the square metre cost are prime factors dictating the choice of the said dimensions.

Figure 2 presents a three dimensional representation of the element . The top and bottom of the cross section are made flat to allow the construction of the elements in the vertical direction as walls or the horizontal direction as slabs.

Figure 3 shows a three dimensional representation of the potential areas of use of the element in building construction, such as walls, floors, roofing slabs, fences, planters, etc..

Figure 4: shows the details of a roof slab with ***Locrete*** elements supported by the structural frame, beams and columns. The ***Locrete*** elements in turn support the topping cast in situ concrete producing a monolithic roof slab of the ***Locrete*** system.

2.2 Reinforcement

Deformed steel bars are used for the reinforcement of the elements. The diameter of the steel bars could vary from 6 mm to 12 mm depending on the desired length of the bar and the required bearing capacity. In mechanised production pre-stressed steel reinforcement can be used, in which case the span and bearing capacity of the element can be increased without any addition in the raw material.

2.3 Weights in Units of Length

The following table is based on a specific gravity of 2350 kg/cubic meter

Length	**Weight in kg**
0.50 meter long	04.90
1.00 meter long	09.80
1.50 meter long	13.70
2.00 meter long	18.60
2.50 meter long	24.50
3.00 meter long	29.40
3.50 meter long	34.30
4.00 meter long	39.20
4.50 meter long	44.10
5.00 meter long	49.00

2.4 Crushing strength

Depending on the structural requirements of the element, the Locrete units crushing

strength can vary between 25 K e.g. for walls to 40 K as in roof slabs.

2.5 The concrete mix

The physical characteristics of the ingredients; sand, gravel, cement, water and the weather temperature are basic contributors to the mix proportions. In most cases the crushing strength of the concrete shall be the decisive factor in identifying the various proportions of the mixes.

Appendix i presents a table suggesting the concrete mix design to be used for building a pilot project.

2.6 The structural design parameters

The ***Locrete*** element has an optimum shape to reduce the materials used without compromising the required structural performance.

The element is designed utilising the requirements of the ACI-318 code of practice.

Appendix ii*:* shows tables of calculations identifying the various structural design parameters for ***Locrete*** and the equation used in the design calculations.

3. <u>MODE OF PRODCUCTION</u>

3.1 Manual Production:

The manual production is well suited for a limited production of the ***Locrete*** elements. For an individual, wishing to construct his/her own home unit, the means and the process of production are simple and straightforward. In fact any one person can produce ***Locrete*** elements in his/her own backyard. The technique is dependent on moulds made out of material that allows multiple use and minimal deterioration .

Locrete elements are produced as follows:

- Procurement or fabrication of moulds
- Arranging moulds in batteries
- Placing reinforcement steel
- Mixing of concrete
- Placing concrete in the mould and vibrating as per standards.
- Casting the reinforced concrete
- Curing and storing

The first step is crucial in the process. Since the invention is intended to minimise the cost of reinforced concrete, it is important that the mould material is obtainable and that

moulds fabricated from such material can be repeatedly used without deterioration. The most suitable materials found for the purpose are GRC or GRP or PVC or Polyethylene moulds cast to the form. The PVC or Polyethylene moulds are made in one piece. And because the mould material is flexible, it allows casting of formwork without disturbing the moulds and or the elements. Moulds may be fabricated to order by any PVC pipe extrusion factory. If pipes of the required measurements are available they may be cut to the form shown in **Figure 1**. Moulds are arranged on specially prepared level casting floor. Reinforcement is set in position. Concrete is then mixed and cast into the moulds. Small size vibrator may be used to vibrate the concrete. Concrete shall be retained in the moulds for a period of three days, during which time the concrete will be regularly cured. The elements would be cast off the moulds and stacked for future use. The moulds will then be rearranged for another cast.

It would be beneficial if the ***Locrete*** units are cast to the lengths required. This can be easily achieved by means of restraining the mould on both ends with removable wooden planks.

Reinforcement bars are laid in the mould and suspended in the required position by means of thin tie wires. The wires keep the reinforcement bars properly positioned while the concrete mix is poured.

The reinforcement bars protrude beyond the wooden planks on both ends of the moulds through a hole that is provided for the purpose. The length of the steel protrusion is a matter of choice and will be used to better tie the Locrete bars to the structural frame. The structural frame can be pre-cast concrete and or cast in situ columns and beams, bearing walls, or steel frame

3.2 Mechanised mode of production

The mechanised mode of production of the ***Locrete*** elements allow production of either:

- Individual elements of lengths that are limited by the span, the deflection allowed and the bearing capacity required, or
- Attached units forming slabs as in **Figure 1** with any practical width that is limited by the width of the machine and the casting bed, and to the length that is limited by the safe span and bearing capacity required of the slabs in production.

The factory set up can be similar to the production line of the hollow core slabs. It follows the same principles of mixing, handling and casting of concrete, i.e. concrete extrusion

kind of operation. The reinforcement bars for the elements are either normal tension bars or pre-stressed bars. The specifications of this invention show the design calculations of the normal reinforcement bars. The performance of the reinforced concrete element is analysed for normal reinforcement and presented in **appendix ii.**

In case of mass production for wide scale commercial purposes, the elements are produced in slabs of various widths and lengths. The slabs range from 1 meter long up to 5 meters long and the width is anywhere between 0.6 meter wide up to 2 meters wide. All dimensions will be limited only by the deflection allowable in relation to the length of the slabs.

The elements can be stacked in a storage yard and sold on order. This allows spontaneous delivery of required material thus contributing to substantial reduction of construction time.

For more efficient operation, slabs or wall elements can be produced to lengths and widths extracted from any building design drawings that are suited to the system.

4. APPLICABILITY: Mode of Construction

The two main uses of the elements are for constructing walls and structural slabs. In the first case, the ***Locrete*** units can be built with or without mortar, depending on the final treatment of the walls. (Figure iii). For the slabs, the ***Locrete*** units will have to be built on structural frames that are either cast in place, or pre-cast or steel frames (Figure iv). After arranging the ***Locrete*** units or slab units in place, the concrete topping shall be poured to the thickness required.

4.1 Walls

In wall construction the element is built horizontally, with or without mortar. In both cases the ***Locrete*** units shall be restrained on both ends by means of a properly sized groove in the concrete columns. The ***Locrete*** elements are laid horizontally. They are either dry or with mortar. The elements will be stacked one on top of the other. The flat face on top of the unit will act as a base for the following unit. Dry construction of ***Locrete*** elements on walls i.e. without mortar mandates that the elements will be plastered in order to weather tighten the walls. Casting the concrete framing columns on site after building the ***Locrete*** elements will allow an integral structural bonding between the ***Locrete*** elements and the frame. This adds substantial structural rigidity to the building frame.

If the columns are built in situ ahead of the *Locrete* elements, then the *Locrete* elements will have to be bonded to the columns by means of mortar. Enough space will be provided in the pre-moulded groove in the column to allow for the bonding mortar.
Windows may be opened in the wall simply by casting the *Locrete* units to the specific dimensions of the design to allow the window opening to be formed. The *Locrete* elements on the window sides are cut to size on site or better pre-fabricated to the required lengths. No special framing system is required for the windows and no lintels will be needed. The Locrete elements once plastered will produce the required window frame thickness.
Depending on the insulation standards required for the building, the necessary insulation material is constructed. Alternatively if the insulation of the exterior is not required, the inner face may be left without any treatment and / or may be plastered to produce a good internal finish face with plaster and paint as per the standard practice. Depending on the design requirements, the exterior walls can be clad with marble, stone, granite, bricks or can be plastered and painted.

Locrete elements can be used as internal partitions too. 15-millimeter thick plaster on each side of the partition will produce a 100-mm thick partition wall.

4.2 Structural slabs

The *Locrete* elements are used in the structural slabs as follows:
Based on the slab plans and the finishing beneath the slabs, the length and the reinforcement of the *Locrete* elements are decided. All fabrication of the elements shall be to the pre-designed, required length. Moreover, cutting the elements to the required length on site is easy and can be achieved by means of an electric disc saw. In such case some waste will have to be allowed for.
The *Locrete* elements are laid horizontally in a butt-joint manner to the full length and width of the slab area. If the clear span between the two end supports of the element is more than 2.5 meters, an intermediary support will have to be temporarily provided until the plain concrete slab topping of the *Locrete* units is poured and cured. Details of the structural characteristics with normal reinforcement are provided in *Appendix ii.*

4.3 Other Functional Utilisations

Further to the established functional utilisation of the ***Locrete*** element in the building construction there are other areas of use that are also functional, these include:

- Fencing posts and runners
- Warehouse wall closure.
- Warehouse roof trusses
- Shoring panels closing between vertical structural supports.
- Pavements substructures
- Fruit trees groves and vineyards.

5. COST IMPLICATIONS: Comparative Analysis

The following table and figures draw a comparative analysis between the ***Locrete*** element and other concrete products, emphasising the economic implications

Table 1: Walls and Slabs Analysis

Description	Linear Meter	Square meter	Steel Reinforcement	US$
Concrete and steel content in one ***Locrete*** unit	0.00417 mc/lm	Walls 0.063 cm/sqm Slabs 0.055 cm/sqm	@6mm 0.226 kg/lm 3.01 kg / sm. 54.87 kg / cm	6.78 / sqm of Walls 107.20 / cm of Walls
1 cubic meter concrete	240 lm.	Walls @ 15.80 sq m./cm Slabs @ 18.00 sq m./cm	@8mm 0.40 kg /lm 5.35 kg / sq m. 97.556 kg/cm	10.00 / sqm Slabs 180.00 / cm in Slabs including 80mm /sq m thickness of plain concrete topping
1 cubic meter in concrete blocks 10*20*40	Not applicable	12.50 units 13.40 /cm	Not applicable	11.00 / sq m.
1 cubic meter in reinforced concrete slab, average thickness 12 cm	Not applicable	8.33 sq m/cm		196.8.00/cm 23.60 / sq m.

Based on the above table:

- ***Locrete*** walls are 61.60% of the standard 100mm thick sand cement blocks.

- *Locrete* slabs are 42.37% of the standard 120mm thick reinforced concrete slabs.

Cost analysis of one cubic meter of *Locrete*[1]

Concrete material	$ 42.00
Reinforcement steel 55 kg. @ $ 249 / Metric Ton	$ 13.695
Allow for casting, curing and transport to site	$ 15.00
Allow for site handling and construction in walls	$ 15.00
Subtotal cost / cubic Meter	$ 85.695
Add 25% for over head and profit	$ 21.42
Locrete total cost / cubic meter	$ 107.20

The following logistic factors are not catered for in the calculations:

Walls

- The block work construction is a wet trade. *Locrete* on the other hand is a dry trade. This will minimise the messiness on sites and will save on water consumption.
- The block work requires plastering in most cases considering the aesthetic side of construction. *Locrete* can stay without plaster on the interior when providing for low cost housing, and still maintains an aesthetically acceptable look.
- Block work requires seven days curing time before it is allowed to be plastered. *Locrete* can be plastered instantly.
- Transportation and mechanical handling costs are also reduced when simply considering that light and less material will be transported.

Slabs

- The labor rate for the carpenters forming slabs estimated at a minimum of US$ 42.80 per cubic meter is eliminated with the Locrete system
- The need for wood and other sundries for formwork at US$ 18 per cubic meter is also eliminated.

[1] Cost is calculated on basis of Kuwait market prices

- A minimum of 30% of the concrete used in the similar span solid slabs will be reduced by one third, yielding a saving in concrete quantity and in reinforcement of US$ 35.00/ cubic meter.
- Total direct saving of labor, formwork and the reduction in quantities in slab concrete and reinforcement steel is US$ 95.80 This will produce a yield saving of approximately 64% of the prevailing cost of cubic meter of concrete of the classical slab system.

In consideration of the substantial direct saving in quantities, there is an indirect saving effect that results from the reduction in the concrete and reinforcement quantities and the dead load resulting from the partitions. A proportional reduction to the foundation and the framing structure will result from the elimination of dead weights on walls and on slabs. This will yield a minimum saving of 25% of the concrete and reinforcement value for the foundations and the framing of the structure. US$ 15.00 per cubic meter in the foundation and the framing system are allowed for in this calculation. To that, one need to add the benefits listed under the previous point of analysis.

6. CONCLUSION

Reinforced concrete is globally considered one of the most utilised material in the construction industry. It is also expensive to acquire in its final form. People in the low-income bracket are the first to suffer from this factor.

The introduction of ***Locrete*** is meant to reach such segment of the world population by giving them a cost-effective and economically viable solution in order to address the issue. The ***Locrete*** solution will help build more for less time and money. ***Locret***e curbs the difficulties involved in the technology to a major extent. It does not eliminate all the problems but makes the solution much more attainable by the end user. It provides a standard solution to the walls and slabs in any standard structure and in particular modular structures.

The fact that the formwork for slabs, and in many parts of the world for wall construction, is relatively eliminated, a major saving on the use of wood for concrete construction purposes is achieved. This, on its own merit, will reflect positively on the issue of world forestry depletion.

7. APPENDICES

Appendix i

Table 1: **Concrete mix design for the pilot project**

Type of concrete K40

Type of cement OPC.

Type of mix PRODUCTION

Materials	Aggregate % - SSD	Volume Ltrs	Spec Gravel vma	SSD Weight kg	Natural Moist %	Water Absorp %	Correct Weight kg
Cement		143	3.15	450			450
Water		185	1	185			173
Admixture			1.11	12.77			13
Air		10					
Fine Aggregate (Sand)		268	2.61	700	5	1	728
Coarse Aggregate ¾"			2.7			1.5	
½"		196	2.7	530		1.5	522
3/8"		204	2.7	550		1.5	542
TOTAL	100%	1018		2428			2428

Water/Cement Ratio: W/C: 0.44

Aggregate/Cement Ratio: A/C: 3.96

- 3.5% of the sand/cement weight polymer is added to the mix to achieve early curing.

Appendix ii:

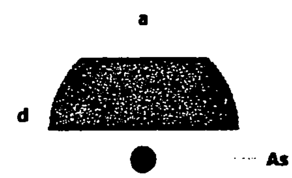
Structural parameters and analysis of the *Locrete* element under different conditions

The design of the element considers the loads and stresses from the following stages:

- Handling
- Casting of concrete topping
- Full service loading in its permanent location

The element is designed utilising the requirements of the ACI-318 code of practice.

The reinforcement percentage in the section is calculated as per the following equation:



$$Mu = \varphi\ fy\ As\ (d - \frac{1}{2}\ \frac{As\ fy}{a\ 0.85\ fc'})\ *$$

Mu = Ultimate moment capacity

$$As = \rho\ \frac{bd}{100}$$

ρ = steel percentage

fy = steel yield strength

fc′ = concrete cylindrical strength at 28 days

φ = 0.9

Deflection limitations as governed by the limits stipulated in ACI – 318 Code of Practice, Chapter 9. Other criteria like general detailing, cover to reinforcement etc. are as per ACI-318 Chapter 7. Local code requirements can be implemented keeping the ACI requirements as the minimum acceptable.

Notes:

- "a" *is the top and bottom flat face dimension of the Locrete element.*
  "As" *is the area of steel section used in reinforcement of the Locrete units.*
  "d" *is the dimension from the bottom of steel reinforcement to the element top face.*
- *The structural design tables are formulated to provide alternatives of cross sectional dimensions, reinforcement, lengths and load bearing capacity. The tables enables the user choose the optimum dimensions of the cross section, the length of the element, The reinforcement and the thickness of the topping required to safely achieve the loading criterion within the permissible deflection limits.*

Locrete: optimisation table and trials for various options
Table 1: section properties

diame	7.51
depth	6.4

x	y	dA	dA.x	dA.x2
0.00	0.00	0.0	0.0	0.0
0.16	2.17	0.3	0.1	0.0
0.32	3.03	0.5	0.2	0.0
0.48	3.67	0.6	0.3	0.1
0.64	4.19	0.7	0.4	0.3
0.80	4.63	0.7	0.6	0.5
0.96	5.02	0.8	0.8	0.7
1.12	5.35	0.9	1.0	1.1
1.28	5.65	0.9	1.2	1.5
1.44	5.91	0.9	1.4	2.0
1.60	6.15	1.0	1.6	2.5
1.76	6.36	1.0	1.8	3.2
1.92	6.55	1.0	2.0	3.9
2.08	6.72	1.1	2.2	4.7
2.24	6.87	1.1	2.5	5.5
2.40	7.00	1.1	2.7	6.5
2.56	7.12	1.1	2.9	7.5
2.72	7.22	1.2	3.1	8.5
2.88	7.30	1.2	3.4	9.7
3.04	7.37	1.2	3.6	10.9
3.20	7.43	1.2	3.8	12.2
3.36	7.47	1.2	4.0	13.5
3.52	7.50	1.2	4.2	14.9
3.68	7.51	1.2	4.4	16.3
3.84	7.51	1.2	4.6	17.7
4.00	7.49	1.2	4.8	19.2
4.16	7.47	1.2	5.0	20.7
4.32	7.42	1.2	5.1	22.2
4.48	7.37	1.2	5.3	23.7
4.64	7.30	1.2	5.4	25.1
4.80	7.21	1.2	5.5	26.6
4.96	7.11	1.1	5.6	28.0
5.12	7.00	1.1	5.7	29.3
5.28	6.86	1.1	5.8	30.6
5.44	6.71	1.1	5.8	31.8
5.60	6.54	1.0	5.9	32.8
5.76	6.35	1.0	5.9	33.7
5.92	6.14	1.0	5.8	34.4
6.08	5.90	0.9	5.7	34.9
6.24	5.63	0.9	5.6	35.1
6.40	5.33	0.9	5.5	34.9
		40.6	**141.1**	**606.4**

Area	**40.6**	cm2
xbar	**3.48**	cm
I xbar	**115.6**	cm4
top w	**5.33**	cm
w avr.	**6.01**	cm
fc'	240	kg/cm2
beta	**0.85**	
Fy	4200	kg/cm2
Ec	**248646**	kg/cm2
n	**8.04**	
cover	2	cm
Mcr	**1024.9**	kg-cm

Table 2: Maximum Element Span Before Cracking

diam	x	Icr	Muc	Mu	Ms	span	Ie	Ie/Ig	defl.
0.6	0.00	38.2	5649	3864	2760	576	39.5	0.34	2.1
0.8	0.00	64.7	5377	5964	3841	562	65.7	0.57	1.1
1.0	0.00	96.1	5111	7583	3651	548	96.5	0.83	0.7
1.2	0.00	131.4	4853	7960	3466	534	131.0	1.13	0.5

Table 3: Variation of Reinforcement Steel Diameter, Concrete Topping, Element Length, Allowable and Actual Deflection and Load Bearing Limit

diam	*topp*	*span*	*Muc*	*Mu*	*Ms*	*ttl cap.*	*ld cap.*	*defl.*	*def lmt*	*LIMIT CPCTY*
0.6	5	500	27829	9208	6577	280.3	26.0	1.9	2.50	25.99
0.8	5	500	27220	15464	11046	470.6	216.4	3.1	2.50	122.96
1.0	5	500	26619	22427	16019	682.6	428.3	4.5	2.50	122.96
1.2	5	500	26024	29335	18589	792.1	537.8	5.2	2.50	122.96
0.6	6	500	34281	10277	7341	312.8	34.5	1.6	2.50	34.52
0.8	6	500	33605	17364	12403	528.5	250.2	2.7	2.50	207.19
1.0	6	500	32937	25396	18140	772.9	494.7	4.0	2.50	207.19
1.2	6	500	32275	33611	23053	982.3	704.0	5.1	2.50	207.19
0.6	7	500	41405	11346	8104	345.3	43.0	1.4	2.50	43.05
0.8	7	500	40662	19264	13760	586.3	284.0	2.4	2.50	284.05
1.0	7	500	39926	28364	20260	863.3	561.0	3.5	2.50	310.37
1.2	7	500	39197	37886	27061	1153.1	850.8	4.7	2.50	310.37
0.6	8	500	49202	12414	8867	377.8	51.6	1.2	2.50	51.58
0.8	8	500	48392	21164	15117	644.1	317.9	2.1	2.50	317.87
1.0	8	500	47588	31333	22381	953.6	627.4	3.1	2.50	434.01
1.2	8	500	46792	42161	30115	1283.2	956.9	4.2	2.50	434.01
0.6	9	500	57670	13483	9631	410.4	60.1	1.1	2.50	60.10
0.8	9	500	56793	23064	16474	702.0	351.7	1.9	2.50	351.70
1.0	9	500	55923	34302	24501	1044.0	693.7	2.8	2.50	579.66
1.2	9	500	55059	46436	33168	1413.3	1063.0	3.8	2.50	579.66
0.6	10	500	66811	14552	10394	442.9	68.6	1.0	2.50	68.63
0.8	10	500	65866	24964	17831	759.8	385.5	1.7	2.50	385.53
1.0	10	500	64929	37271	26622	1134.4	760.1	2.5	2.50	748.83
1.2	10	500	63998	50711	36222	1543.4	1169.2	3.4	2.50	748.83

Table 3: *cont'd*

diam	*topp*	*span*	*Muc*	*Mu*	*Ms*	*ttl cap.*	*ld cap.*	*defl.*	*def lmt*	*LIMIT CPCTY*
0.6	5	450	27829	9208	6577	346.0	91.7	1.5	2.25	91.73
0.8	5	450	27220	15464	11046	581.0	326.8	2.5	2.25	263.19
1.0	5	450	26619	22427	16019	842.7	588.4	3.7	2.25	263.19
1.2	5	450	26024	29335	18589	977.8	723.6	4.3	2.25	263.19
0.6	6	450	34281	10277	7341	386.1	107.9	1.3	2.25	107.89
0.8	6	450	33605	17364	12403	652.4	374.2	2.2	2.25	374.18
1.0	6	450	32937	25396	18140	954.2	676.0	3.2	2.25	387.66
1.2	6	450	32275	33611	23053	1212.7	934.4	4.1	2.25	387.66
0.6	7	450	41405	11346	8104	426.3	124.0	1.1	2.25	124.05
0.8	7	450	40662	19264	13760	723.8	421.6	1.9	2.25	421.57
1.0	7	450	39926	28364	20260	1065.8	763.5	2.9	2.25	538.11
1.2	7	450	39197	37886	27061	1423.5	1121.3	3.8	2.25	538.11
0.6	8	450	49202	12414	8867	466.5	140.2	1.0	2.25	140.20
0.8	8	450	48392	21164	15117	795.2	469.0	1.7	2.25	468.97
1.0	8	450	47588	31333	22381	1177.3	851.1	2.5	2.25	716.64
1.2	8	450	46792	42161	30115	1584.2	1257.9	3.4	2.25	716.64

diam	*topp*	*span*	*Muc*	*Mu*	*Ms*	*ttl cap.*	*ld cap.*	*defl.*	*def lmt*	*LIMIT CPCTY*
0.6	5	400	27829	9208	6577	437.9	183.6	1.2	2.00	183.63
0.8	5	400	27220	15464	11046	735.4	481.1	2.0	2.00	481.13
1.0	5	400	26619	22427	16019	1066.5	812.3	2.9	2.00	482.50
1.2	5	400	26024	29335	18589	1237.6	983.3	3.4	2.00	482.50
0.6	6	400	34281	10277	7341	488.7	210.5	1.0	2.00	210.46
0.8	6	400	33605	17364	12403	825.7	547.5	1.7	2.00	547.48
1.0	6	400	32937	25396	18140	1207.7	929.4	2.5	2.00	669.89
1.2	6	400	32275	33611	23053	1534.8	1256.6	3.2	2.00	669.89
0.6	7	400	41405	11346	8104	539.5	237.3	0.9	2.00	237.28
0.8	7	400	40662	19264	13760	916.1	613.8	1.5	2.00	613.84
1.0	7	400	39926	28364	20260	1348.9	1046.6	2.3	2.00	894.28
1.2	7	400	39197	37886	27061	1801.7	1499.4	3.0	2.00	894.28
0.6	8	400	49202	12414	8867	590.4	264.1	0.8	2.00	264.11
0.8	8	400	48392	21164	15117	1006.5	680.2	1.4	2.00	680.20
1.0	8	400	47588	31333	22381	1490.1	1163.8	2.0	2.00	1158.65
1.2	8	400	46792	42161	30115	2005.0	1678.7	2.7	2.00	1158.65

Table 3: ***cont'd***

diam	topp	span	Muc	Mu	Ms	ttl cap.	ld cap.	defl.	def lmt	LIMIT CPCTY
0.6	5	350	27829	9208	6577	571.9	317.7	0.9	1.75	317.68
0.8	5	350	27220	15464	11046	960.5	706.2	1.5	1.75	706.25
1.0	5	350	26619	22427	16019	1393.0	1138.7	2.2	1.75	845.51
1.2	5	350	26024	29335	18589	1616.4	1362.2	2.6	1.75	845.51
0.6	6	350	34281	10277	7341	638.3	360.1	0.8	1.75	360.06
0.8	6	350	33605	17364	12403	1078.5	800.3	1.3	1.75	800.26
1.0	6	350	32937	25396	18140	1577.4	1299.1	2.0	1.75	1137.05
1.2	6	350	32275	33611	23053	2004.7	1726.4	2.5	1.75	1137.05
0.6	7	350	41405	11346	8104	704.7	402.4	0.7	1.75	402.45
0.8	7	350	40662	19264	13760	1196.5	894.3	1.2	1.75	894.28
1.0	7	350	39926	28364	20260	1761.8	1459.6	1.7	1.75	1459.55
1.2	7	350	39197	37886	27061	2353.2	2050.9	2.3	1.75	1483.82
0.6	8	350	49202	12414	8867	771.1	444.8	0.6	1.75	444.83
0.8	8	350	48392	21164	15117	1314.6	988.3	1.0	1.75	988.30
1.0	8	350	47588	31333	22381	1946.2	1620.0	1.5	1.75	1619.95
1.2	8	350	46792	42161	30115	2618.7	2292.5	2.1	1.75	1890.28

diam	topp	span	Muc	Mu	Ms	ttl cap.	ld cap.	defl.	def lmt	LIMIT CPCTY
0.6	5	300	27829	9208	6577	778.5	524.2	0.7	1.50	524.21
0.8	5	300	27220	15464	11046	1307.4	1053.1	1.1	1.50	1053.10
1.0	5	300	26619	22427	16019	1896.0	1641.8	1.6	1.50	1492.13
1.2	5	300	26024	29335	18589	2200.2	1945.9	1.9	1.50	1492.13
0.6	6	300	34281	10277	7341	868.8	590.6	0.6	1.50	590.57
0.8	6	300	33605	17364	12403	1468.0	1189.7	1.0	1.50	1189.73
1.0	6	300	32937	25396	18140	2147.0	1868.8	1.4	1.50	1868.77
1.2	6	300	32275	33611	23053	2728.6	2450.3	1.8	1.50	1969.20
0.6	7	300	41405	11346	8104	959.2	656.9	0.5	1.50	656.93
0.8	7	300	40662	19264	13760	1628.6	1326.4	0.9	1.50	1326.37
1.0	7	300	39926	28364	20260	2398.0	2095.8	1.3	1.50	2095.76
1.2	7	300	39197	37886	27061	3203.0	2900.7	1.7	1.50	2533.97
0.6	8	300	49202	12414	8867	1049.5	723.3	0.4	1.50	723.29
0.8	8	300	48392	21164	15117	1789.3	1463.0	0.8	1.50	1463.00
1.0	8	300	47588	31333	22381	2649.0	2322.8	1.1	1.50	2322.75
1.2	8	300	46792	42161	30115	3564.4	3238.1	1.5	1.50	3193.52

Table 3: ***cont'd***

diam	*topp*	*span*	*Muc*	*Mu*	*Ms*	*ttl cap.*	*ld cap.*	*defl.*	*def lmt*	*LIMIT CPCTY*
0.6	5	250	27829	9208	6577	1121.0	866.7	0.5	1.25	866.74
0.8	5	250	27220	15464	11046	1882.6	1628.3	0.8	1.25	1628.33
1.0	5	250	26619	22427	16019	2730.3	2476.0	1.1	1.25	2476.03
1.2	5	250	26024	29335	18589	3168.2	2914.0	1.3	1.25	2763.51
0.6	6	250	34281	10277	7341	1251.1	972.9	0.4	1.25	972.86
0.8	6	250	33605	17364	12403	2113.9	1835.6	0.7	1.25	1835.65
1.0	6	250	32937	25396	18140	3091.7	2813.5	1.0	1.25	2813.46
1.2	6	250	32275	33611	23053	3929.2	3650.9	1.3	1.25	3605.36
0.6	7	250	41405	11346	8104	1381.2	1079.0	0.4	1.25	1078.97
0.8	7	250	40662	19264	13760	2345.2	2043.0	0.6	1.25	2042.96
1.0	7	250	39926	28364	20260	3453.2	3150.9	0.9	1.25	3150.89
1.2	7	250	39197	37886	27061	4612.3	4310.0	1.2	1.25	4310.03
0.6	8	250	49202	12414	8867	1511.3	1185.1	0.3	1.25	1185.09
0.8	8	250	48392	21164	15117	2576.5	2250.3	0.5	1.25	2250.28
1.0	8	250	47588	31333	22381	3814.6	3488.3	0.8	1.25	3488.32
1.2	8	250	46792	42161	30115	5132.7	4806.5	1.1	1.25	4806.49

diam	*topp*	*span*	*Muc*	*Mu*	*Ms*	*ttl cap.*	*ld cap.*	*defl.*	*def lmt*	*LIMIT CPCTY*
0.6	5	200	27829	9208	6577	1751.6	1497.3	0.3	1.00	1497.31
0.8	5	200	27220	15464	11046	2941.5	2687.3	0.5	1.00	2687.29
1.0	5	200	26619	22427	16019	4266.1	4011.8	0.7	1.00	4011.82
1.2	5	200	26024	29335	18589	4950.3	4696.1	0.8	1.00	4696.08
0.6	6	200	34281	10277	7341	1954.9	1676.6	0.3	1.00	1676.61
0.8	6	200	33605	17364	12403	3303.0	3024.7	0.4	1.00	3024.72
1.0	6	200	32937	25396	18140	4830.8	4552.6	0.6	1.00	4552.55
1.2	6	200	32275	33611	23053	6139.3	5861.1	0.8	1.00	5861.08
0.6	7	200	41405	11346	8104	2158.2	1855.9	0.2	1.00	1855.91
0.8	7	200	40662	19264	13760	3664.4	3362.1	0.4	1.00	3362.15
1.0	7	200	39926	28364	20260	5395.5	5093.3	0.6	1.00	5093.29
1.2	7	200	39197	37886	27061	7206.7	6904.4	0.8	1.00	6904.44
0.6	8	200	49202	12414	8867	2361.5	2035.2	0.2	1.00	2035.22
0.8	8	200	48392	21164	15117	4025.8	3699.6	0.3	1.00	3699.58
1.0	8	200	47588	31333	22381	5960.3	5634.0	0.5	1.00	5634.02
1.2	8	200	46792	42161	30115	8019.9	7693.7	0.7	1.00	7693.65

LOCRETE DESIGN DRAWINGS

- **Figure 1/4:** Details for wall & ceiling moulds cross section dimensions, wall & ceiling element cross section dimensions, pre-cast slab and walls cross sections representation, individual elements slab cross section representation.
- **Figure 2/4:** 3-D representation of element in walls.
- **Figure 3/4:** 3-D representation of element applications in walls, slabs, internal partitions, fence and planters etc.
- **Figure 4/4:** 3-D representation of element and topping in roof slabs.

THE CLAIMS

The claims defining the invention are as follows:

1. A pre-cast reinforced concrete element comprising a particular design in terms of form, dimensions, single bar reinforcement and method of fabrication and construction.

2. The pre-cast reinforced concrete element of claim 1 with its specific cross section design and dimensions, provides an optimum form that renders efficient utilisation of the pre-cast reinforced concrete material, in that it reduces the material used while it fulfils the requirements of the structural performance.

3. The pre-cast reinforced concrete element of claim 1, when combined, forms a non-load bearing wall and structural slab system.

4. The wall and structural slab system of claim 2 wherein walls are constructed by stacking the elements in vertical direction with the flat surfaces horizentally laid and the ends of each element are fitted with sand-cement mortar in a specially provided groove in the framing columns.

5. The wall and structural slab system of claim 2 wherein slabs are constructed by horizentally placing individual elements in a butt-jointed manner, supported on both ends by structural framing beams to form a diaphragm , over which plain concrete of predetermined thickness, is cast in situ to achieve a monolithic structure.

6. The pre-cast reinforced concrete element of claim 1, when manually produced, is best poured in moulds made of PVC or similar durable, reusable material .

A pre-cast reinforced concrete element substantially as herein described with reference to the accompanying drawings.

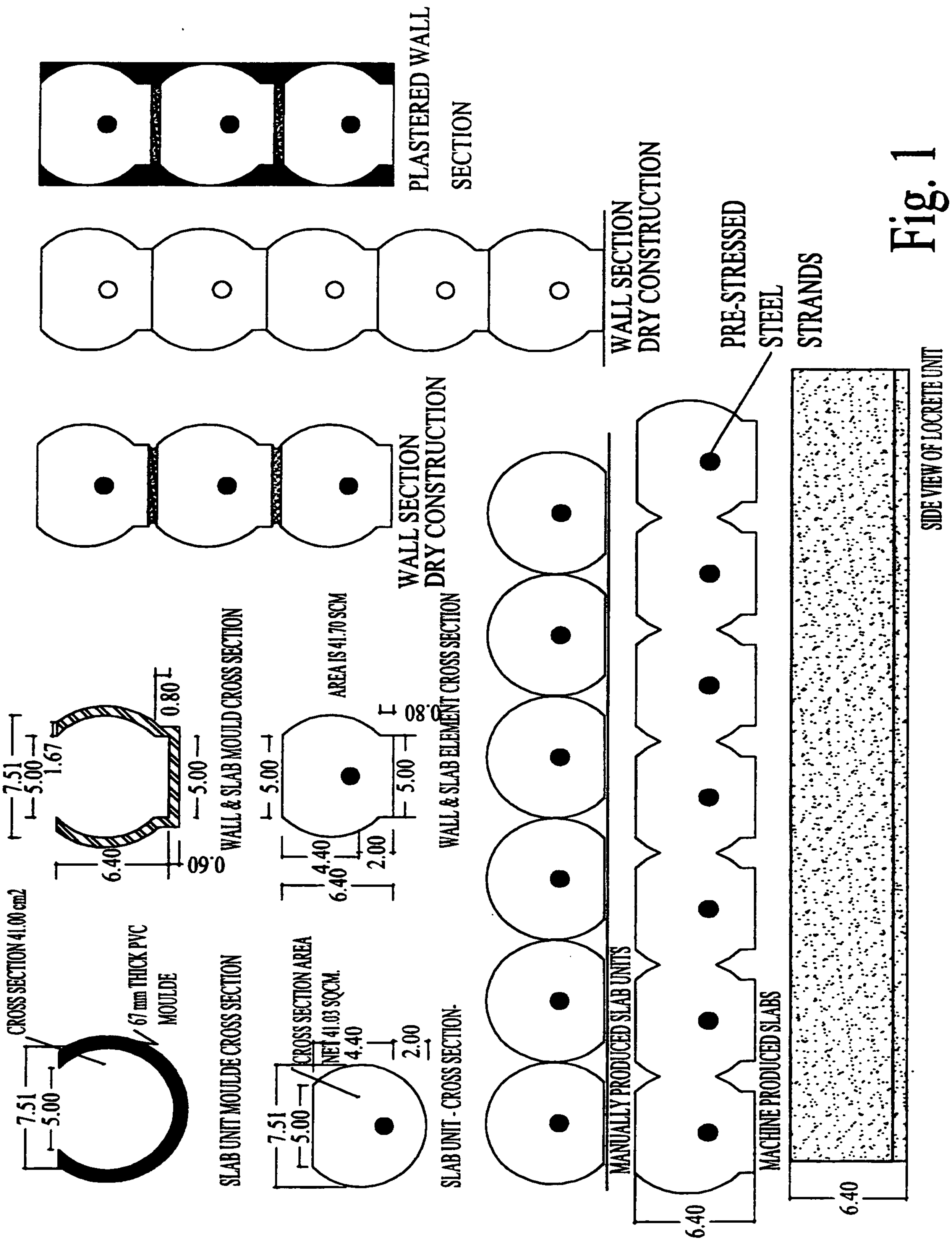

PLASTERED WALL
SECTION
WALL SECTION
DRY CONSTRUCTION
WALL SECTION
DRY CONSTRUCTION
PRE-STRESSED
STEEL
STRANDS
SIDE VIEW OF LOCRETE UNIT
MACHINE PRODUCED SLABS
MANUALLY PRODUCED SLAB UNITS
CROSS SECTION 41.00 cm2
67 mm THICK PVC
MOULDE
SLAB UNIT MOULDE CROSS SECTION
CROSS SECTION AREA
NET 41.03 SQCM.
SLAB UNIT - CROSS SECTION-
WALL & SLAB MOULD CROSS SECTION
AREA IS 41.70 SCM
WALL & SLAB ELEMENT CROSS SECTION
7.51
5.00
4.40
2.00
6.40
1.67
0.80
0.60

Fig. 1

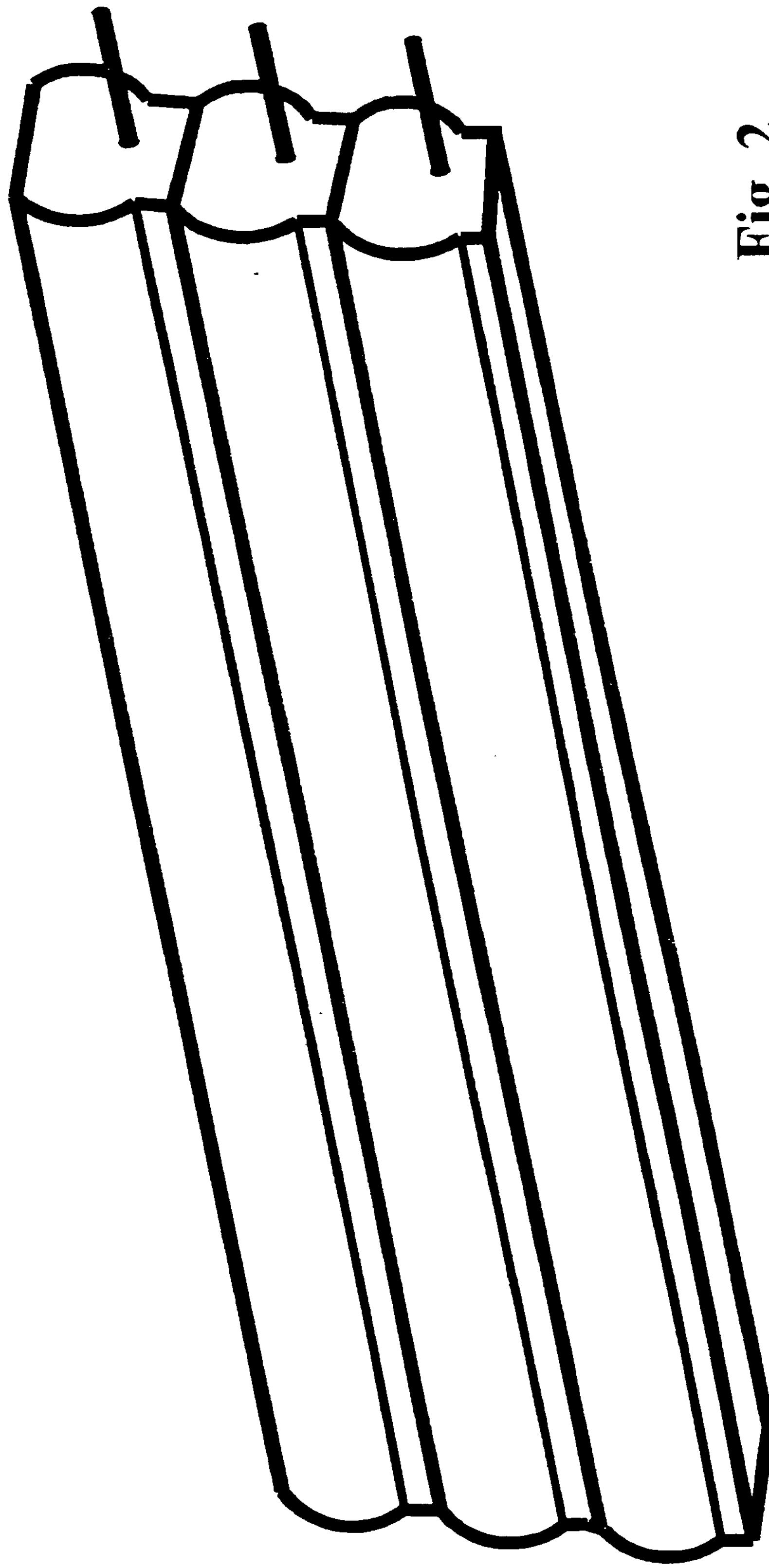


Fig. 2

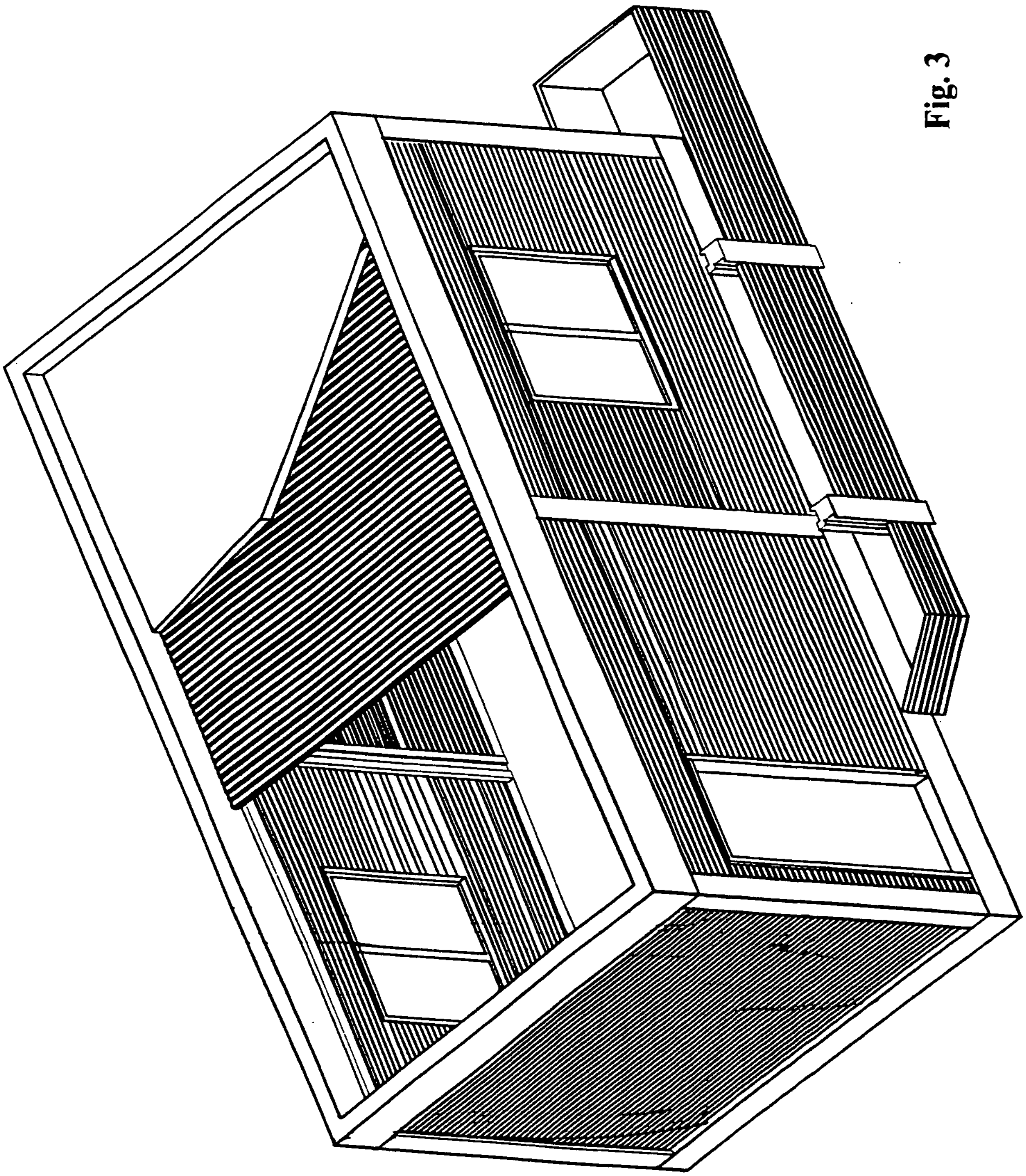
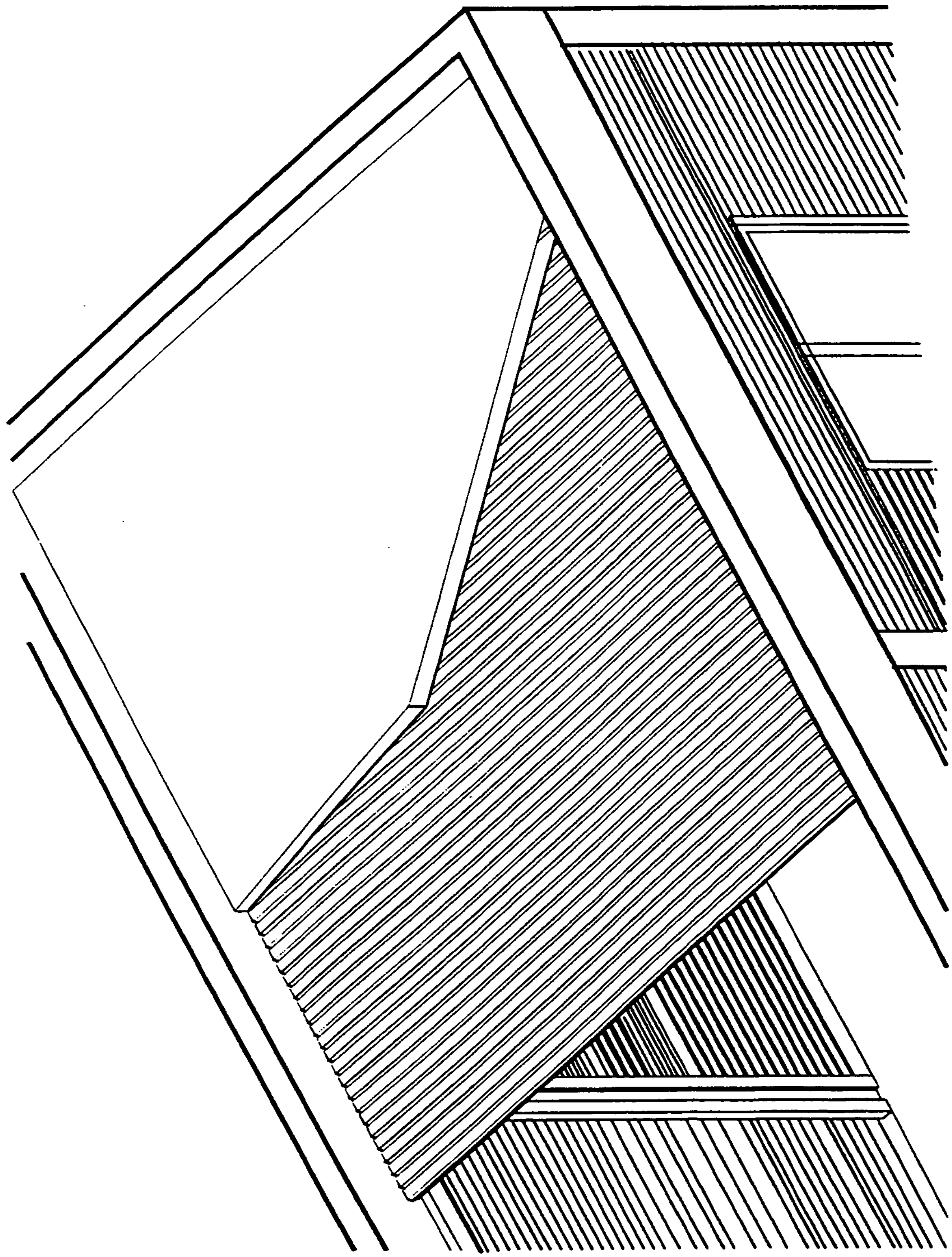


Fig. 3

Fig. 4



INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 99/01929

A.	**CLASSIFICATION OF SUBJECT MATTER**
Int Cl^{6}:	E04B 2/66, 2/12, 5/06, 5/36, 5/14, E04C 2/30, 2/40, 3/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC E04B 2/-, 5/-, E04C 2/-, 3/20

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU: IPC AS ABOVE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPAT:
JAPIO:

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Patent Abstracts of Japan, JP, 10-061100 A (KAJIMA CORP) 3 March 1998	1-6
X	Derwent Abstract Accession No. A2173 K/01, Class Q44 SU 905401 A (LATV CONS RES EXP) 15 February 1982	1-6
X	FR 2282515 A (DAVUM) 19 March 1976 Figures 1 -3	1-3, 5, 6

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 January 2000	18 JAN 2000

Name and mailing address of the ISA/AU	Authorized officer
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	**S. TITUS** Telephone No.: (02) 6283 2122

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 99/01929

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	BE 820202 A (BULTE) 16 January 1975 Figures 1-5	1-2, 5, 6
X	US 4485604 A (PALAMARA et al.) 4 December 1984 entire document	1-3
X	US 4300746 A (SCHOEN) 17 November 1981 entire document	1,2
X	EP 362892 A (DYCKERHOFF & WIDMANN) 9 August 1989 Figures 1-17	1,2
X	US 4288955 A (HIATT et al.) 15 September 1981 column 5, lines 45-62, Figures 5, 18	1,2
A	DE 1609361 A (KIRCHHOFF) 10 April 1975	

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IB 99/01929

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	44856040	AT	15706	DE	3266274	EP	60230
		IN	157971	IT	8147978	IT	1218259
US	4957395	AT	119229	AU	620012	CA	1317120
		DE	69017364	EP	429637	WO	90/15903
US	4300746	CA	1130993				
EP	326892	AT	73887	DE	3802964	DK	168798

END OF ANNEX

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 513634:GMT:EIG	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416).
International Application No. **PCT/IB99/01929**	International Filing Date *(day/month/year)* 3 December 1999	Priority Date *(day/month/year)* 7 July 1999
International Patent Classification (IPC) or national classification and IPC **Int. Cl.** [7] E04B 2/66, 2/12, 5/06, 5/36, 5/14, E04C 2/30, 2/40, 3/20		
Applicant KASSIS, Fahim		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 5 sheets, including this cover sheet.

   [X] This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 23 sheet(s).

3. This report contains indications relating to the following items:

I	[X]	Basis of the report
II	[ ]	Priority
III	[X]	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
IV	[ ]	Lack of unity of invention
V	[X]	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
VI	[ ]	Certain documents cited
VII	[ ]	Certain defects in the international application
VIII	[ ]	Certain observations on the international application

Date of submission of the demand 30 January 2001	Date of completion of the report 23 August 2001
Name and mailing address of the IPEA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized Officer JOHN HO Telephone No. (02) 6283 2329

INTERNATIONAL PRELIMIN[redacted] EXAMINATION REPORT

International application No.
PCT/IB99/01929

I.	**Basis of the report**

1. With regard to the **elements** of the international application:*
   - [ ] the international application as originally filed.
   - [X] the description, pages , as originally filed,
     pages , filed with the demand,
     pages **1-16,** received on **7 May 2001** with the letter of **7 May 2001**
   - [X] the claims, pages , as originally filed,
     pages , as amended (together with any statement) under Article 19,
     pages , filed with the demand,
     pages **17,** received on **7 May 2001** with the letter of **7 May 2001**
   - [X] the drawings, pages , as originally filed,
     pages , filed with the demand,
     pages **1/6-6/6,** received on **7 May 2001** with the letter of **7 May 2001**
   - [ ] the sequence listing part of the description:
     pages , as originally filed
     pages , filed with the demand
     pages , received on with the letter of

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
   These elements were available or furnished to this Authority in the following language which is:
   - [ ] the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).
   - [ ] the language of publication of the international application (under Rule 48.3(b)).
   - [ ] the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:
   - [ ] contained in the international application in written form.
   - [ ] filed together with the international application in computer readable form.
   - [ ] furnished subsequently to this Authority in written form.
   - [ ] furnished subsequently to this Authority in computer readable form.
   - [ ] The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - [ ] The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

4. [ ] The amendments have resulted in the cancellation of:
   - [ ] the description, pages
   - [ ] the claims, Nos.
   - [ ] the drawings, sheets/fig.

5. [X] This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

** *Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report*

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/IB99/01929

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be nonobvious), or to be industrially applicable have not been examined in respect of:

☐ the entire international application,

☒ claims Nos: **1-2**

because:

☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination *(specify)*:

☐ the description, claims or drawings *(indicate particular elements below)* or said claims Nos. are so unclear that no meaningful opinion could be formed *(specify)*:

☒ the claims, or said claims Nos. **1-2** are so inadequately supported by the description that no meaningful opinion could be formed.

☒ no international search report has been established for said claim Nos. **1-2**

2. A meaningful international preliminary examination cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

☐ the written form has not been furnished or does not comply with the standard.

☐ the computer readable form has not been furnished or does not comply with the standard.

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims 3-5	YES
	Claims -	NO
Inventive step (IS)	Claims 3-5	YES
	Claims -	NO
Industrial applicability (IA)	Claims 3-5	YES
	Claims -	NO

2. Citations and explanations (Rule 70.7)

The following documents identified in the International Search Report have been considered for the purposes of this report:

- Derwent Abstract Accession No. A2173 K/01, Class Q44, SU 905401 A (LATV CONS RES EXP)

New Citations:

- AU 12939/44 A (MONOFORM FLOORS) 22 August 1946
- AU 25115/35 A (CLOUGHTON) 18 June 1936
- AU 40034/64 A (NATIONAL RESEARCH DEVELOPMENT CORP) 22 July 1965
- AU 11935/52 A (STRESSSTEEL CORP) 16 October 1952

None of the above citations either individually or in combination disclose a pre-cast concrete element with generally planar upper and lower surfaces having longitudinally extending convex side surfaces joining the upper and lower surfaces and wherein a reinforcing element extends within and between the end surfaces.

A concrete element having a single reinforcement is known as evident from the disclosure in each of the above citations. The closest art of AU 40034/64 discloses concrete elements formed adjacent one another and having reinforcing rods. However, there is no disclosure of the shape as defined in claim 3.

Therefore, the subject matter of these claims is new and meets the requirements of Article 33(2) of the PCT with regard to the requirement for novelty.

The claimed invention is also not obvious in light of any of the cited documents nor disclosed in any obvious combination, nor would the claimed invention be obvious to a person skilled in the art in the light of common general knowledge by itself or in combination with any of these documents.

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of Box I

This opinion has been established as if some of the amendments had not been made, since they have been considered to go beyond the disclosure as filed.

Specifically, the specification as filed clearly relates to a pre-cast concrete element having a single bar reinforcement formed therein. See for instance the claims as filed as well as the description (as filed) at page 3 lines 13-17, page 5 lines 16-23, page 6 lines 1-4 and the drawing sheets 1-2. There is no suggestion that the concrete element could be formed without any reinforcement as defined by the present claims 1-2.

The initial search carried out by the ISA was also in relation to a single-bar reinforced concrete element. The search did not extend to concrete elements which do not have any reinforcements as presently defined by claims 1-2.

Therefore, this opinion is restricted to the claims which defines a concrete element having a single reinforcement element (ie. claim 3, and claims 4-5 when appended to claim 3).

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REINFORCED CONCRETE ELEMENT

Technical Field of the Invention

The present invention relates to a reinforced concrete element.

Background of the Invention

Reinforced concrete elements are generally used as building construction material for walls and slabs.

The predominant techniques used in reinforced concrete construction are mostly based on previously set models. The technical research on reinforced concrete as a building construction material is extensive with particular emphasis placed on its physical performance. Most of the applications in the field utilise heavy equipment, extensive amounts of formwork or a combination of both. Advanced technical know how is required but may not be readily available. All of these factors result in prohibitive or redundant costs.

Unfortunately, reinforced concrete is expensive. These costs are due to factors such as: cost of technical expertise, cost of design, supervision and skilled labour; cost of materials and material handling; equipment and labour; formwork and related labour; and construction time.

It would therefore be desirable to have a reinforced concrete element which is designed such that it maximises the benefits of the material and concurrently reduces costs.

Object of the Invention

It is an object of the present invention to overcome or ameliorate some of the disadvantages of the prior art or at least to provide a useful alternative.

Summary of the Invention

There is firstly disclosed herein an elongated pre-cast concrete element, said element having:

longitudinally extending upper and lower generally parallel surfaces that enable the element to be stacked with like elements when horizontally oriented; and

longitudinally extending convex side surfaces joining the upper and lower surfaces.

There is further disclosed herein a wall structure including a plurality of elements, each element being an element as hereinbefore defined, wherein the elements are stacked so each element is generally horizontally oriented.

The present invention, at least in a preferred embodiment preferably achieves the following: the elimination of formwork for reinforced concrete slabs resulting in a direct cost saving and a positive environmental impact; the elimination of mandatory use of heavy equipment, intensive labour and advanced technical expertise; the substantial reduction in capital investment as a result of major savings achieved through the use of the elements alternative building material; and substantial reduction in the time required for fabrication and construction of walls and slabs.

Therefore, the present invention is preferably a pre-designed, pre-cast reinforced concrete element that is characterised by its cross sectional form. In an individual form, the elements can be utilised for other purposes such as walls of a building structure, partition walls, fencing, planters, tree support posts, pavements, retaining walls, etc.

The present invention is yet further preferably easy to transport and handle without the use of heavy equipment.

Preferably, the present invention is economical to fabricate and build and is generally maintenance free.

Brief Description of the Drawings

A preferred embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings, wherein:

Figures 1a and 1b are cross-sectional views of two alternate embodiments of the element according to the present invention;

Figures 1c and 1d are cross-sectional view of moulds for the construction of the elements shown in Figures 1a and 1b respectively;

Figure 1e is a side view of an element;

Figures 1f and 1g are side views of a series of elements in accordance with Figures 1a and 1b forming a slab;

Figure 1h is a side view of a series of elements in accordance with Figure 1a, forming a free standing wall;

Figure 1i is a side view of a series of elements in accordance with Figure 1a, forming a wall where the elements are cemented together;

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Figure 1j is a side view of a series of elements in accordance with Figure 1a, forming a plastered wall;

Figure 2 is a perspective view of a series of elements in accordance with Figure 1a;

Figure 3 is a partial 3-dimensional view of a house showing use of a series of elements; and

Figure 4 is a partial 3-dimensional cut away view of the roof of the house of Figure 3.

Detailed Description of the Preferred Embodiments

In Figures 1A, 1I to 1J and 2 there is depicted a preferred elongate pre-cast concrete element 5. The element 5 has longitudinally extending upper and lower generally parallel surfaces 10, 15 that enable the elements 5 to be stacked as shown, for example, in Figures 1I to 1J vertically to form a wall. The element 5 further includes longitudinally extending convex side surfaces 20 joining the upper and lower surfaces 10, 15 to define a cross-section 17. A longitudinal passage 25 is located centrally and extends between end surfaces 12, 13 and is adapted for receipt for a reinforcing element such as reinforced steel bar 30.

The convex sides 20 are designed to provide excellent load bearing capabilities. The preferred cross section 17 of the element 5 has dimensions 64 mm high and 75mm wide resulting in a cross sectional area 17 of the element 5 of 4170 square millimetres. The length of the element 5 can be any length, but generally between 100mm and 5000mm. Advantageously, the width and height of the cross section 17 can be varied to suite the required increase or decrease in the bearing capacity of the element 5. Accordingly, construction using the elements allows an optimal combination between the element cross sectional dimensions and its bearing capacity, with the only constant being the cross sectional design 17. These can be determined by the following:

Structural Parameters And Analysis Of The Element Under Different Conditions

The design of the element 5 considers the loads and stresses from the following stages:

- Handling
- Cast of concrete topping
- Full service loading in its permanent location

The element is designed utilising the requirements of the ACI-318 code of practice.

The reinforcement percentage in the section is calculated as per the following equation:

$$Mu = \varphi\, fy\, As\,(d - \frac{1}{2}\,\frac{As\, fy}{a\, 0.85\, fc'})^{*}$$

Mu = Ultimate moment capacity

$$As = \rho\,\frac{bd}{100}$$

ρ = steel percentage

fy = steel yield strength

fc' = concrete cylindrical strength at 28 days

$\varphi = 0.9$

Deflection limitations as governed by the limits stipulated in ACI-318 Code of Practice, Chapter 9. Other criteria like general detailing, cover to reinforcement etc. are as per ACI-318, Chapter 7. Local code requirements can be implemented keeping the ACI requirements as the minimum acceptable.

Notes:

- "a" is the upper and lower flat surfaces 10, 15 dimension of the element 5.
- "As" is the area of steel section used in reinforcement 30 of the element 5.
- "d" is the direction from the bottom of steel reinforcement 30 to the element upper surface 10.

A number of structural design tables have been formulated to provide alternatives of cross sectional dimensions, reinforcement, lengths and load bearing capacity. The tables located herein on pages 12 to 16 enable the user to choose the optimum dimensions of the cross section 17 and the length of the element 5. From the tables it can be seen that the linear metre weight of a single element, the load bearing

capacity, the square metre cost are prime factors dictating the choice of the required dimensions.

In a preferred embodiment, steel bars 30 can be used for the reinforcement of the element 5. The diameter of the steel bars 30 and the passage 25 could vary from 6mm to 12mm depending on the desired length of the bar and the required bearing capacity. In mechanised production pre-stressed steel reinforcement can be used, in which case the span and bearing capacity of the element can be increased without any addition in the raw material.

The elements are preferably able to be handled without the need for heavy equipment. The following table is based on a specific gravity of 2350 kg/cubic meter and illustrates the weights per length of a preferred form of the elements.

Length	**Weight in kg**
0.50 meter long	04.90
1.00 meter long	09.80
1.50 meter long	13.70
2.00 meter long	18.60
2.50 meter long	24.50
3.00 meter long	29.40
3.50 meter long	34.30
4.00 meter long	39.20
4.50 meter long	44.10
5.00 meter long	49.00

These elements also preferably have crushing strengths varying between 25 K e.g. for walls to 40 K as in roof slabs. In this regard, the physical characteristics of the ingredients; sand, gravel, cement, water and the weather temperature are basic contributors to the mix. In most cases, the crushing strength of the concrete will be the decisive factor in identifying the various proportions of the mix. The Table below sets out the concrete mix used for building the pilot project.

Table 1: Concrete Mix Design For The Pilot Project

Type of concrete K40

Type of cement OPC.

Type of mix PRODUCTION

Materials	Aggregate % - SSD	Vol. Ltrs	Spec Gravel vma	SSD Weight kg	Natural Moist %	Water Absorp %	Correct Weight kg
Cement		143	3.15	450			450
Water		185	1	185			173
Admixture			1.11	12.77			13
Air		10					
Fine Aggregate (Sand)		268	2.61	700	5	1	728
Coarse Aggregate ¾"			2.7			1.5	
½"		196	2.7	530		1.5	522
3/8"		204	2.7	550		1.5	542
TOTAL	100%	1018		2428			2428

Turning now to the mode of production of the element 5, manual and mechanised methods are presently contemplated. The manual production is well suited for a limited production of the elements. For an individual, wishing to construct his/her own home unit, the means and the process of production are dependent upon moulds 40, shown in Figures 1c and 1d and are made out of material that allows multiple use and minimal deterioration.

Elements 5 could be produced as follows: procurement or fabrication of moulds 40; arranging moulds in batteries; placing reinforcement steel 30; mixing of concrete; placing concrete in the mould 40 and vibrating as per standards; casting the reinforced concrete; curing and storing. As preferably, the invention is intended to minimise the cost of reinforced concrete elements, it is important that the mould material is obtainable and that moulds fabricated from such material can be readily used without deterioration. The most suitable materials found for the purpose are GRC or GRP or PVC or Polyethylene moulds cast to the form. The PVC or Polyethylene moulds are made in one piece and

because the mould material is flexible, it allows casting of formwork without disturbing the moulds and/or the elements and easy removal of the mould after use.

Generally, moulds 40 are arranged on specially prepared level casting floors, reinforcement is set in position, concrete is mixed and then cast into the moulds. Small size vibrators may be used to vibrate the concrete. The concrete should be retained in the moulds for a period of about three days, during which time the concrete will be cured. The elements could then be removed from the moulds and stacked for future use. The moulds can then be rearranged for another cast.

If reinforcement is required the steel bars are laid in the mould and suspended in the required position by means of thin tie wires (not shown) or other suitable means. The wires keep the reinforcement bars properly positioned while the concrete mix is poured. The reinforcement bars should protrude beyond the ends of the moulds. The reinforcing could also be added later by casting a recess as in the preferred embodiment.

Another presently contemplated mode of production is the mechanised mode where the elements are produced on mass in a factory. Any practical length and width is possible only being limited by the length and width of the machines and the casting bed. The factory set up can be similar to the production line of hollow core slabs. The same principles of mixing, handling and casting of concrete apply. That is, it can be a concrete extrusion operation. The reinforcement bars for the elements can be either normal tension bars or pre-stressed bars. In the preferred embodiment of this invention normal reinforcement bars are used. In the case of mass production for wide scale commercial purposes, the elements can be produced in slabs of various widths and lengths. The slabs can range from 1 metre in length up to 5 metres and the width is anywhere between 0.6 metre wide up to 2 metres wide. All dimensions will generally be limited only by the deflection allowable in relation to the length of the slabs. The elements can be stacked in a storage yard and sold on order. This allows spontaneous delivery of required material thus contributing to substantial reduction of construction time.

There are two main uses presently contemplated for the elements 5; constructing walls 50 and structural slabs 55. In the first case, and as shown in Figures 1h to 1j, the elements 5 can be assembled with or without mortar/cement 45, depending on the final treatment of the walls 50. For the slabs 55, as shown in Figure 1g, the elements 5 can be built on structural frames 57 and either cast in place, pre-cast or a steel frame. After arranging the elements 5 in place, a concrete topping 59 (see Figures 3 and 4) could be

poured to the thickness required. Further, as shown in Figures 1B and 1G the upper surface may be rounded 60.

As shown in Figures 1h to 1j, when constructing wall 50 the elements 5 stacked vertically, with or without mortar 45. The elements 5 can be restrained on both horizontal ends by concrete columns 65 as shown in Figures 3 and 4. The elements 5 are then laid therebetween, either dry or with mortar 45 one on top of the other. In this arrangement, the upper surface 10 on top of the element 5 will act as a base for the following element 5. Dry construction of the elements 5 in walls 50 will usually include plaster 62 on the outside in order to weather tighten the walls 50. Further, casting the concrete framing columns 65 on site after building the elements 5 will allow an integral structural bonding between the elements 5 and the frame. This adds substantial structural rigidity to the building frame. If, however, the columns 65 are built in situ ahead of the elements 5, then the elements 5 will have to be bonded to the columns 65 by means of mortar 45. Enough space for this procedure can be provided by placing a pre-moulded groove 69 in the column to allow for the bonding mortar.

In embodiments including housing construction, windows 70 may be opened in the wall 50 simply by casting the elements 5 to the specific dimensions required to allow the window opening to be formed. The elements can be cut to size on site or better pre-fabricated to the required lengths. No special framing system is required for the windows and no lintels will be needed. The elements once plastered will produce the required window frame thickness. Depending on the insulation standards required for the building, the necessary insulation material is constructed. Alternatively if the insulation of the exterior is not required, the inner face may be left without any treatment and/or may be plastered to produce a good internal finish face with plaster and paint as per the standard practice. Depending upon the design requirements, the exterior walls can be clad with marble, stone, granite, bricks or can be plastered and painted.

It is also foreshadowed that elements can be used as internal partitions too. Further, about 15 millimetres of plaster on each side of the partition will produce a 100 mm thick partition wall.

If considering structural slabs 55, as shown in Figures 1e to 1g, based on the slab plans and the finishing beneath the slabs, the length and the reinforcement of the elements 5 are decided; all fabrication of the elements should be to the pre-designed, required length. Moreover, cutting the elements to the required length on site is easy and can be achieved by means of an electric disc saw. The elements 5 are laid horizontally to the full

length and width of the slab area. If the clear span between the two end supports of the element is more than 2.5 metres, an intermediary support should be temporarily provided until the plain concrete slab topping 59 of the elements 5 is poured and cured.

Further to the above, the elements 5 can be used in fencing posts and runners; warehouse wall closure; warehouse roof trusses; shoring panels closing between vertical structural supports; pavements substructures; and fruit trees groves and vineyards, however, they are not limited to only these uses.

As cost is important in the construction industry the following table and figures draw a comparative analysis between the elements of the present invention at least in a preferred embodiment and other concrete products, emphasising the economic implications.

Table A: Walls and Slab Analysis

Description	Linear Metre	Square Metre	Steel Reinforcement	US$
Concrete and steel content in one element.	0.00417 mc/lm	Walls 0.063 cm/sqm Slabs 0.055 cm/sqm	@6mm 0.226 kg/lm 3.01 kg/sm. 54.87 kg/cm	6.78/sqm of Walls 107.20/cm of Walls
1 cubic metre concrete.	240 lm.	Walls @ 15.80 sq m./cm Slabs @ 18.00 sq m/cm	@8mm 0.40 kg/lm 5.35 kg/sq m. 97.556 kg/cm	10.00/sqm Slabs 180.00/cm in Slabs including 80mm sq m thickness concrete topping of plain concrete topping
1 cubic metre in concrete blocks 10*20*40.	Not applicable	12.50 units 13.40/cm	Not applicable	11.00/sq m.
1 cubic metre in reinforced concrete slab, average thickness 12cm.	Not applicable	8.33 sq m/cm		196.8.00/cm 23.60/sq m.

Upon analysis of the above table it can be seen that, walls constructed using the elements of the present invention cost 61.60% of the standard 100mm thick sand cement blocks and slabs cost 42.37% of the standard 120mm thick reinforced concrete slabs.

The cost analysis of one cubic meter displayed in the table (cost is calculated on basis of Kuwait market prices) was calculated as follows:

Concrete material	\$ 42.00
Reinforced steel 55 kg. @ \$249 / Metric Ton	\$ 13.69
Allow for casting, curing and transport to site	\$ 15.00
Allow for site handling and construction in walls	\$ 15.00
Sub-total cost/cubic Metre:	\$ 85.69
Add 25% for overhead and profit	\$ 21.42
Total cost/cubic metre	\$ 107.20.

Further differences with the present invention is that normal block work construction is a "wet" trade whilst the present invention is a "dry" trade. This minimises the messiness on sites and will save on water consumption. Most block work requires plastering. The elements of the present invention can stay without plaster on the interior, for example, when providing for low cost housing, and still maintain an aesthetically acceptable look. Further, block work requires seven days curing time before it is allowed to be plastered whilst the elements can be plastered instantly. Still further, the transportation and mechanical handling costs are also reduced when simply considering that light and less material will be transported.

Further, when constructing slabs the labour rate for carpenters forming slabs is estimated at a minimum of US\$42.80 per cubic metre and this is eliminated with the elements of the present invention. The need for wood and other sundries for formwork at US\$18 per cubic metre is also preferably eliminated. A minimum of 30% of the concrete used in similar span solid slabs will be reduced by one third, yielding a saving in concrete quantity and in reinforcement of US\$35.00/cubic metre. Total direct saving of labour, formwork and the reduction in quantities in slab concrete and reinforcement steel is US\$95.80. This will produce a yield saving of approximately 64% of the prevailing cost of cubic metre of concrete of the classical slab system.

In consideration of the substantial direct savings mentioned above, there is an indirect saving effect that results from the reduction in the concrete and reinforcement quantities and the dead load. A proportional reduction to the foundation and the framing structure will result from the elimination of dead weights on walls and on slabs. This will

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yield a minimum saving of 25% of the concrete and reinforcement value for the foundations and the framing of the structure. It is contemplated that there would be US$15.00 per cubic metre in the foundation and the framing system.

As reinforced concrete is globally considered one of the most utilised material in the construction industry and is also expensive to acquire in its final form, people in the low-income bracket would be substantially advantaged to use such a product.

The element of the present invention is directed towards a segment of the world's population by giving them a cost-effective and economically viable solution in order to address the cost issues and the difficulties involved in advanced technology. It does not eliminate all the problems but makes the solution much more attainable by the end user. It provides a standard solution to the construction of walls and slabs in any standard structure and in particular modular structures. The fact that the formwork for slabs, and in many parts of the world for wall construction, is relatively eliminated, a major saving on the use of wood for concrete construction purposes is achieved. This, on its own merit, will reflect positively on the issue of world forestry depletion.

Although the invention has been described with reference to specific examples, it would be appreciated by those skilled in the art that the invention may be embodied in many other forms.

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Locrete: optimisation table and trials for various options
Table 1: section properties

diame	7.51
depth	6.4

x	y	dA	dA.x	dA.x2
0.00	0.00	0.0	0.0	0.0
0.16	2.17	0.3	0.1	0.0
0.32	3.03	0.5	0.2	0.0
0.48	3.67	0.6	0.3	0.1
0.64	4.19	0.7	0.4	0.3
0.80	4.63	0.7	0.6	0.5
0.96	5.02	0.8	0.8	0.7
1.12	5.35	0.9	1.0	1.1
1.28	5.65	0.9	1.2	1.5
1.44	5.91	0.9	1.4	2.0
1.60	6.15	1.0	1.6	2.5
1.76	6.36	1.0	1.8	3.2
1.92	6.55	1.0	2.0	3.9
2.08	6.72	1.1	2.2	4.7
2.24	6.87	1.1	2.5	5.5
2.40	7.00	1.1	2.7	6.5
2.56	7.12	1.1	2.9	7.5
2.72	7.22	1.2	3.1	8.5
2.88	7.30	1.2	3.4	9.7
3.04	7.37	1.2	3.6	10.9
3.20	7.43	1.2	3.8	12.2
3.36	7.47	1.2	4.0	13.5
3.52	7.50	1.2	4.2	14.9
3.68	7.51	1.2	4.4	16.3
3.84	7.51	1.2	4.6	17.7
4.00	7.49	1.2	4.8	19.2
4.16	7.47	1.2	5.0	20.7
4.32	7.42	1.2	5.1	22.2
4.48	7.37	1.2	5.3	23.7
4.64	7.30	1.2	5.4	25.1
4.80	7.21	1.2	5.5	26.6
4.96	7.11	1.1	5.6	28.0
5.12	7.00	1.1	5.7	29.3
5.28	6.86	1.1	5.8	30.6
5.44	6.71	1.1	5.8	31.8
5.60	6.54	1.0	5.9	32.8
5.76	6.35	1.0	5.9	33.7
5.92	6.14	1.0	5.8	34.4
6.08	5.90	0.9	5.7	34.9
6.24	5.63	0.9	5.6	35.1
6.40	5.33	0.9	5.5	34.9
		40.6	141.1	606.4

Area	40.6	cm2
xbar	3.48	cm
I xbar	115.6	cm4
top w	5.33	cm
w avr.	6.01	cm
fc'	240	kg/cm2
beta	0.85	
Fy	4200	kg/cm2
Ec	248646	kg/cm2
n	8.04	
cover	2	cm
Mcr	1024.9	kg-cm

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Table 2: Maximum Element Span Before Cracking

diam	x	Icr	Muc	Mu	Ms	span	Ie	Ie/Ig	defl.
0.6	0.00	38.2	5649	3864	2760	576	39.5	0.34	2.1
0.8	0.00	64.7	5377	5964	3841	562	65.7	0.57	1.1
1.0	0.00	96.1	5111	7583	3651	548	96.5	0.83	0.7
1.2	0.00	131.4	4853	7960	3466	534	131.0	1.13	0.5

Table 3: Variation of Reinforcement Steel Diameter, Concrete Topping, Element Length, Allowable and Actual Deflection and Load Bearing Limit

diam	*topp*	*span*	*Muc*	*Mu*	*Ms*	*ttl cap.*	*ld cap.*	*defl.*	*def lmt*	*LIMIT CPCTY*
0.6	5	500	27829	9208	6577	280.3	26.0	1.9	2.50	25.99
0.8	5	500	27220	15464	11046	470.6	216.4	3.1	2.50	122.96
1.0	5	500	26619	22427	16019	682.6	428.3	4.5	2.50	122.96
1.2	5	500	26024	29335	18589	792.1	537.8	5.2	2.50	122.96
0.6	6	500	34281	10277	7341	312.8	34.5	1.6	2.50	34.52
0.8	6	500	33605	17364	12403	528.5	250.2	2.7	2.50	207.19
1.0	6	500	32937	25396	18140	772.9	494.7	4.0	2.50	207.19
1.2	6	500	32275	33611	23053	982.3	704.0	5.1	2.50	207.19
0.6	7	500	41405	11346	8104	345.3	43.0	1.4	2.50	43.05
0.8	7	500	40662	19264	13760	586.3	284.0	2.4	2.50	284.05
1.0	7	500	39926	28364	20260	863.3	561.0	3.5	2.50	310.37
1.2	7	500	39197	37886	27061	1153.1	850.8	4.7	2.50	310.37
0.6	8	500	49202	12414	8867	377.8	51.6	1.2	2.50	51.58
0.8	8	500	48392	21164	15117	644.1	317.9	2.1	2.50	317.87
1.0	8	500	47588	31333	22381	953.6	627.4	3.1	2.50	434.01
1.2	8	500	46792	42161	30115	1283.2	956.9	4.2	2:50	434.01
0.6	9	500	57670	13483	9631	410.4	60.1	1.1	2.50	60.10
0.8	9	500	56793	23064	16474	702.0	351.7	1.9	2.50	351.70
1.0	9	500	55923	34302	24501	1044.0	693.7	2.8	2.50	579.66
1.2	9	500	55059	46436	33168	1413.3	1063.0	3.8	2.50	579.66
0.6	10	500	66811	14552	10394	442.9	68.6	1.0	2.50	68.63
0.8	10	500	65866	24964	17831	759.8	385.5	1.7	2.50	385.53
1.0	10	500	64929	37271	26622	1134.4	760.1	2.5	2.50	748.83
1.2	10	500	63998	50711	36222	1543.4	1169.2	3.4	2.50	748.83

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Table 3: *cont'd*

diam	*topp*	*span*	*Muc*	*Mu*	*Ms*	*ttl cap.*	*ld cap.*	*defl.*	*def lmt*	*LIMIT CPCTY*
0.6	5	450	27829	9208	6577	346.0	91.7	1.5	2.25	91.73
0.8	5	450	27220	15464	11046	581.0	326.8	2.5	2.25	263.19
1.0	5	450	26619	22427	16019	842.7	588.4	3.7	2.25	263.19
1.2	5	450	26024	29335	18589	977.8	723.6	4.3	2.25	263.19
0.6	6	450	34281	10277	7341	386.1	107.9	1.3	2.25	107.89
0.8	6	450	33605	17364	12403	652.4	374.2	2.2	2.25	374.18
1.0	6	450	32937	25396	18140	954.2	676.0	3.2	2.25	387.66
1.2	6	450	32275	33611	23053	1212.7	934.4	4.1	2.25	387.66
0.6	7	450	41405	11346	8104	426.3	124.0	1.1	2.25	124.05
0.8	7	450	40662	19264	13760	723.8	421.6	1.9	2.25	421.57
1.0	7	450	39926	28364	20260	1065.8	763.5	2.9	2.25	538.11
1.2	7	450	39197	37886	27061	1423.5	1121.3	3.8	2.25	538.11
0.6	8	450	49202	12414	8867	466.5	140.2	1.0	2.25	140.20
0.8	8	450	48392	21164	15117	795.2	469.0	1.7	2.25	468.97
1.0	8	450	47588	31333	22381	1177.3	851.1	2.5	2.25	716.64
1.2	8	450	46792	42161	30115	1584.2	1257.9	3.4	2.25	716.64

diam	*topp*	*span*	*Muc*	*Mu*	*Ms*	*ttl cap.*	*ld cap.*	*defl.*	*def lmt*	*LIMIT CPCTY*
0.6	5	400	27829	9208	6577	437.9	183.6	1.2	2.00	183.63
0.8	5	400	27220	15464	11046	735.4	481.1	2.0	2.00	481.13
1.0	5	400	26619	22427	16019	1066.5	812.3	2.9	2.00	482.50
1.2	5	400	26024	29335	18589	1237.6	983.3	3.4	2.00	482.50
0.6	6	400	34281	10277	7341	488.7	210.5	1.0	2.00	210.46
0.8	6	400	33605	17364	12403	825.7	547.5	1.7	2.00	547.48
1.0	6	400	32937	25396	18140	1207.7	929.4	2.5	2.00	669.89
1.2	6	400	32275	33611	23053	1534.8	1256.6	3.2	2.00	669.89
0.6	7	400	41405	11346	8104	539.5	237.3	0.9	2.00	237.28
0.8	7	400	40662	19264	13760	916.1	613.8	1.5	2.00	613.84
1.0	7	400	39926	28364	20260	1348.9	1046.6	2.3	2.00	894.28
1.2	7	400	39197	37886	27061	1801.7	1499.4	3.0	2.00	894.28
0.6	8	400	49202	12414	8867	590.4	264.1	0.8	2.00	264.11
0.8	8	400	48392	21164	15117	1006.5	680.2	1.4	2.00	680.20
1.0	8	400	47588	31333	22381	1490.1	1163.8	2.0	2.00	1158.65
1.2	8	400	46792	42161	30115	2005.0	1678.7	2.7	2.00	1158.65

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Table 3: *cont'd*

diam	*topp*	*span*	*Muc*	*Mu*	*Ms*	*ttl cap.*	*ld cap.*	*defl.*	*def lmt*	*LIMIT CPCTY*
0.6	5	350	27829	9208	6577	571.9	317.7	0.9	1.75	317.68
0.8	5	350	27220	15464	11046	960.5	706.2	1.5	1.75	706.25
1.0	5	350	26619	22427	16019	1393.0	1138.7	2.2	1.75	845.51
1.2	5	350	26024	29335	18589	1616.4	1362.2	2.6	1.75	845.51
0.6	6	350	34281	10277	7341	638.3	360.1	0.8	1.75	360.06
0.8	6	350	33605	17364	12403	1078.5	800.3	1.3	1.75	800.26
1.0	6	350	32937	25396	18140	1577.4	1299.1	2.0	1.75	1137.05
1.2	6	350	32275	33611	23053	2004.7	1726.4	2.5	1.75	1137.05
0.6	7	350	41405	11346	8104	704.7	402.4	0.7	1.75	402.45
0.8	7	350	40662	19264	13760	1196.5	894.3	1.2	1.75	894.28
1.0	7	350	39926	28364	20260	1761.8	1459.6	1.7	1.75	1459.55
1.2	7	350	39197	37886	27061	2353.2	2050.9	2.3	1.75	1483.82
0.6	8	350	49202	12414	8867	771.1	444.8	0.6	1.75	444.83
0.8	8	350	48392	21164	15117	1314.6	988.3	1.0	1.75	988.30
1.0	8	350	47588	31333	22381	1946.2	1620.0	1.5	1.75	1619.95
1.2	8	350	46792	42161	30115	2618.7	2292.5	2.1	1.75	1890.28

diam	*topp*	*span*	*Muc*	*Mu*	*Ms*	*ttl cap.*	*ld cap.*	*defl.*	*def lmt*	*LIMIT CPCTY*
0.6	5	300	27829	9208	6577	778.5	524.2	0.7	1.50	524.21
0.8	5	300	27220	15464	11046	1307.4	1053.1	1.1	1.50	1053.10
1.0	5	300	26619	22427	16019	1896.0	1641.8	1.6	1.50	1492.13
1.2	5	300	26024	29335	18589	2200.2	1945.9	1.9	1.50	1492.13
0.6	6	300	34281	10277	7341	868.8	590.6	0.6	1.50	590.57
0.8	6	300	33605	17364	12403	1468.0	1189.7	1.0	1.50	1189.73
1.0	6	300	32937	25396	18140	2147.0	1868.8	1.4	1.50	1868.77
1.2	6	300	32275	33611	23053	2728.6	2450.3	1.8	1.50	1969.20
0.6	7	300	41405	11346	8104	959.2	656.9	0.5	1.50	656.93
0.8	7	300	40662	19264	13760	1628.6	1326.4	0.9	1.50	1326.37
1.0	7	300	39926	28364	20260	2398.0	2095.8	1.3	1.50	2095.76
1.2	7	300	39197	37886	27061	3203.0	2900.7	1.7	1.50	2533.97
0.6	8	300	49202	12414	8867	1049.5	723.3	0.4	1.50	723.29
0.8	8	300	48392	21164	15117	1789.3	1463.0	0.8	1.50	1463.00
1.0	8	300	47588	31333	22381	2649.0	2322.8	1.1	1.50	2322.75
1.2	8	300	46792	42161	30115	3564.4	3238.1	1.5	1.50	3193.52

Table 3: *cont'd*

diam	topp	span	Muc	Mu	Ms	ttl cap.	ld cap.	defl.	def lmt	LIMIT CPCTY
0.6	5	250	27829	9208	6577	1121.0	866.7	0.5	1.25	866.74
0.8	5	250	27220	15464	11046	1882.6	1628.3	0.8	1.25	1628.33
1.0	5	250	26619	22427	16019	2730.3	2476.0	1.1	1.25	2476.03
1.2	5	250	26024	29335	18589	3168.2	2914.0	1.3	1.25	2763.51
0.6	6	250	34281	10277	7341	1251.1	972.9	0.4	1.25	972.86
0.8	6	250	33605	17364	12403	2113.9	1835.6	0.7	1.25	1835.65
1.0	6	250	32937	25396	18140	3091.7	2813.5	1.0	1.25	2813.46
1.2	6	250	32275	33611	23053	3929.2	3650.9	1.3	1.25	3605.36
0.6	7	250	41405	11346	8104	1381.2	1079.0	0.4	1.25	1078.97
0.8	7	250	40662	19264	13760	2345.2	2043.0	0.6	1.25	2042.96
1.0	7	250	39926	28364	20260	3453.2	3150.9	0.9	1.25	3150.89
1.2	7	250	39197	37886	27061	4612.3	4310.0	1.2	1.25	4310.03
0.6	8	250	49202	12414	8867	1511.3	1185.1	0.3	1.25	1185.09
0.8	8	250	48392	21164	15117	2576.5	2250.3	0.5	1.25	2250.28
1.0	8	250	47588	31333	22381	3814.6	3488.3	0.8	1.25	3488.32
1.2	8	250	46792	42161	30115	5132.7	4806.5	1.1	1.25	4806.49

diam	topp	span	Muc	Mu	Ms	ttl cap.	ld cap.	defl.	def lmt	LIMIT CPCTY
0.6	5	200	27829	9208	6577	1751.6	1497.3	0.3	1.00	1497.31
0.8	5	200	27220	15464	11046	2941.5	2687.3	0.5	1.00	2687.29
1.0	5	200	26619	22427	16019	4266.1	4011.8	0.7	1.00	4011.82
1.2	5	200	26024	29335	18589	4950.3	4696.1	0.8	1.00	4696.08
0.6	6	200	34281	10277	7341	1954.9	1676.6	0.3	1.00	1676.61
0.8	6	200	33605	17364	12403	3303.0	3024.7	0.4	1.00	3024.72
1.0	6	200	32937	25396	18140	4830.8	4552.6	0.6	1.00	4552.55
1.2	6	200	32275	33611	23053	6139.3	5861.1	0.8	1.00	5861.08
0.6	7	200	41405	11346	8104	2158.2	1855.9	0.2	1.00	1855.91
0.8	7	200	40662	19264	13760	3664.4	3362.1	0.4	1.00	3362.15
1.0	7	200	39926	28364	20260	5395.5	5093.3	0.6	1.00	5093.29
1.2	7	200	39197	37886	27061	7206.7	6904.4	0.8	1.00	6904.44
0.6	8	200	49202	12414	8867	2361.5	2035.2	0.2	1.00	2035.22
0.8	8	200	48392	21164	15117	4025.8	3699.6	0.3	1.00	3699.58
1.0	8	200	47588	31333	22381	5960.3	5634.0	0.5	1.00	5634.02
1.2	8	200	46792	42161	30115	8019.9	7693.7	0.7	1.00	7693.65

The claims defining the invention are as follows:

1. An elongated pre-cast concrete element, said element having:

longitudinally extending upper and lower generally parallel surfaces that enable the element to be stacked with like elements when horizontally oriented; and

longitudinally extending convex side surfaces joining the upper and lower surfaces.

2. The element of claim 1, further having end surfaces and a longitudinal passage extending between said end surfaces.

3. The element of claim 2, further including a reinforcing element located in said passage so as to extend between said end surfaces.

4. A wall structure including a plurality of elements, each element being an element according to claims 1, 2 or 3, wherein the elements are stacked so each element is generally horizontally oriented.

5. The wall structure according to claim 4, whereby between adjacent upper and lower surfaces of adjoining elements is a layer of mortar or cement.

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Fahim Kassis

Patent Attorneys for the Applicant/Nominated Person
SPRUSON & FERGUSON

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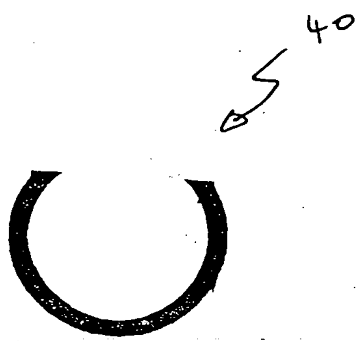

FIG. 1C

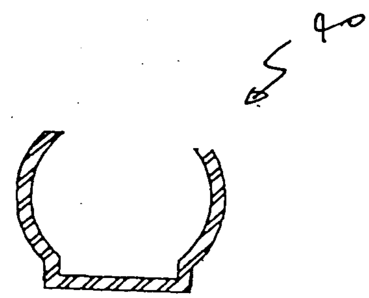

FIG. 1D

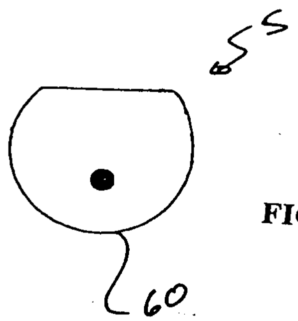

FIG. 1B

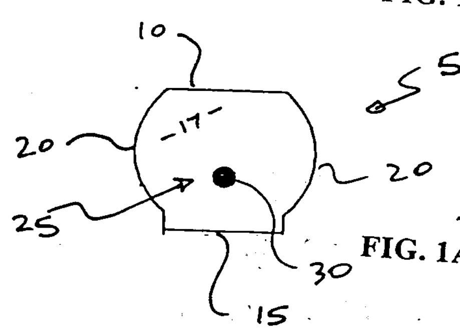

FIG. 1A

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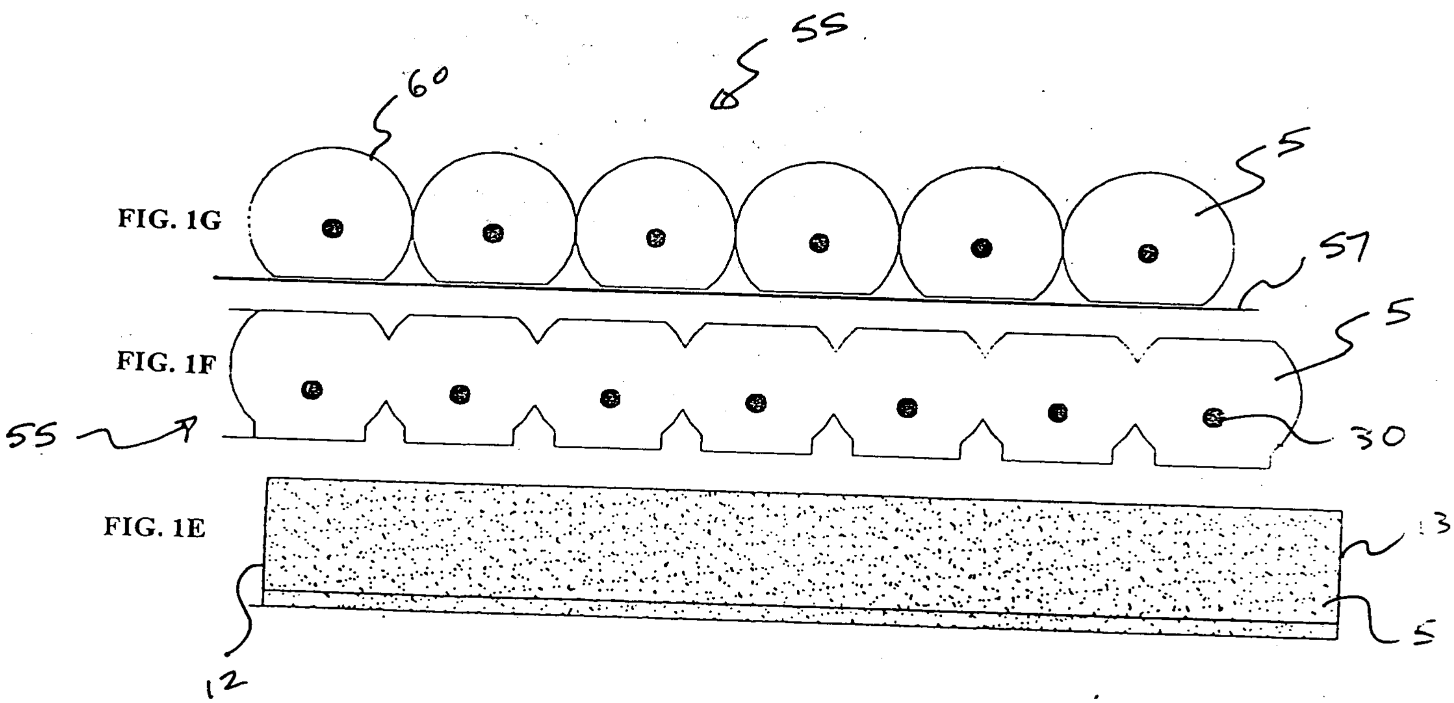
FIG. 1G

FIG. 1F

FIG. 1E



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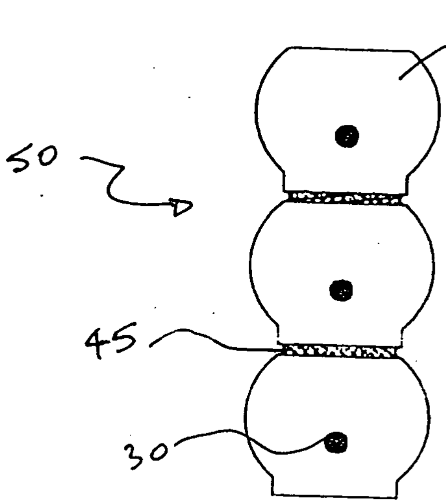

FIG. 1I

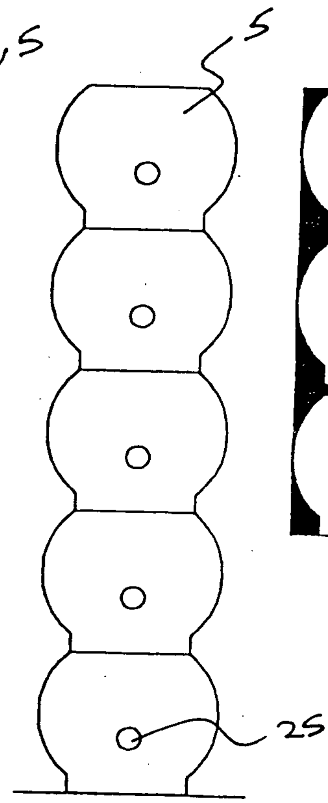

FIG. 1H

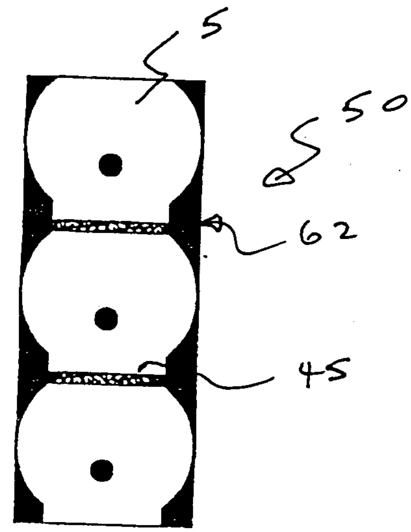

FIG. 1J

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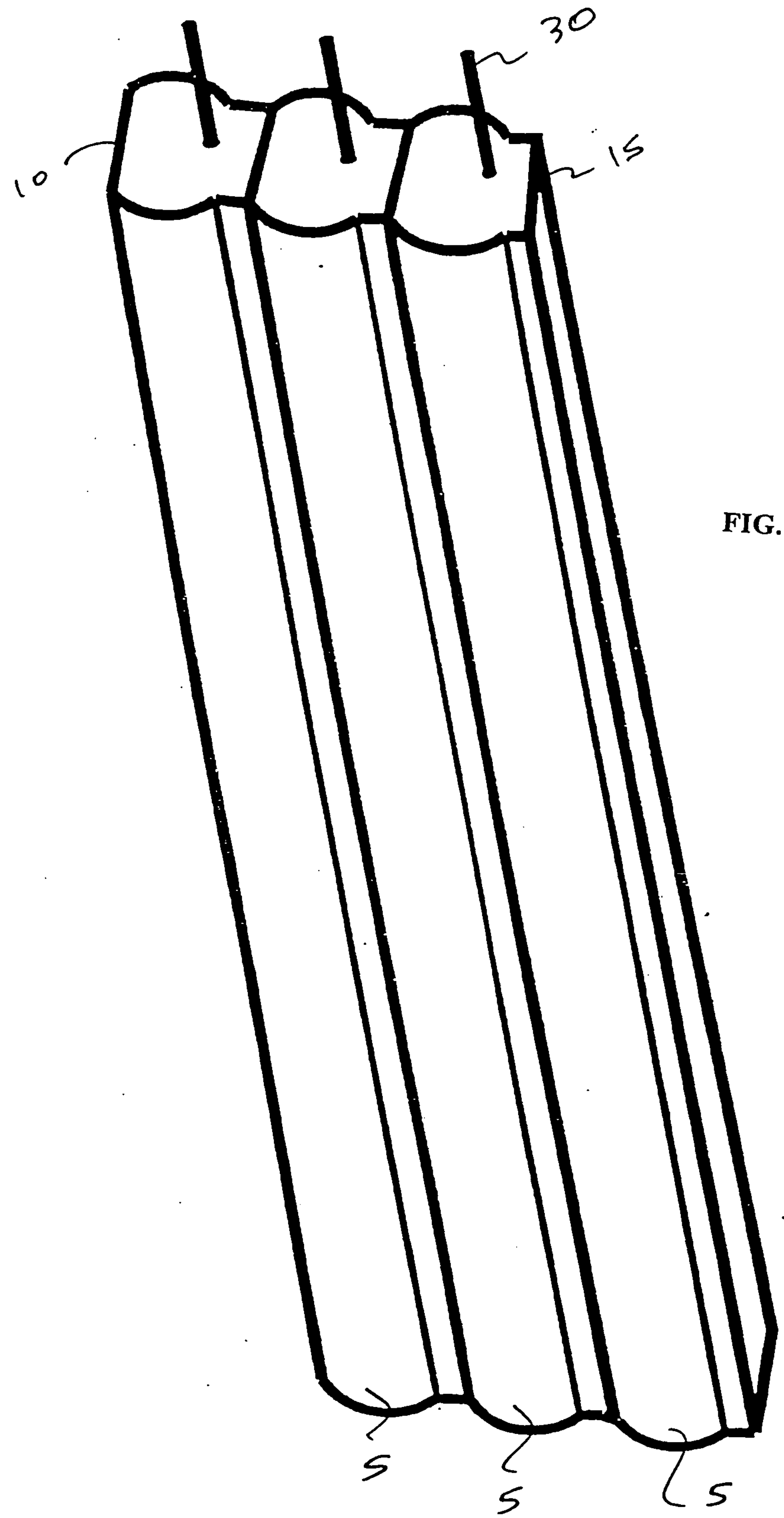

FIG. 2

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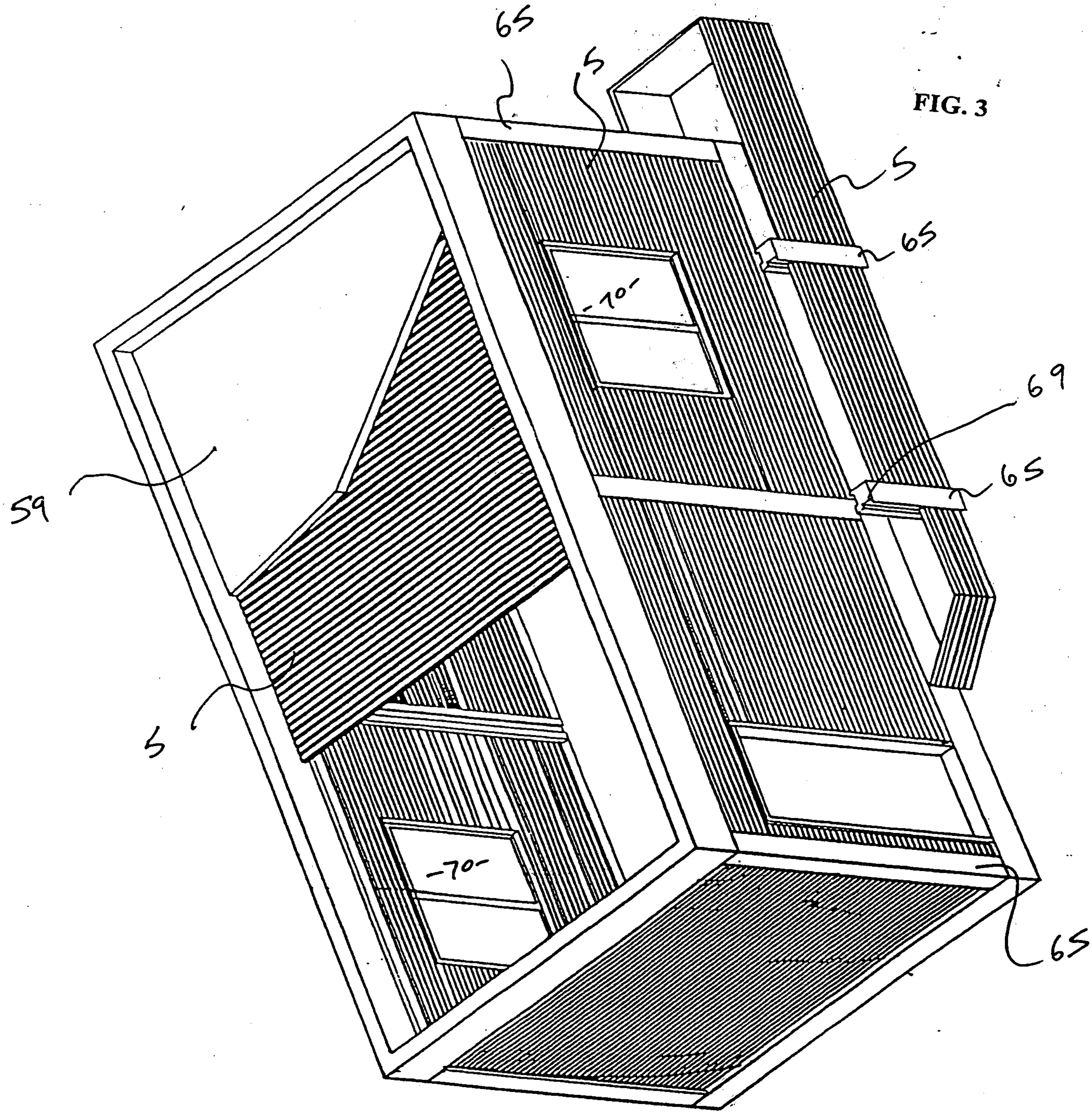

FIG. 3

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FIG. 4